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The Magazine of Hydraulic and Air Circuit Engineering

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COUPLING OR TORQUE CONVERTER? PAGE 10

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Production Department
WILLIAM V. LINAS
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Director

Editorial and Business Office
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Cleveland 13, Ohio
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W. PAUL PINCHER
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New York 18, N. Y.
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FRONT COVER: The B-36, world's largest bomber, with six 3000 hp pusher engines can carry 10,000 pounds of bombs for 10,000 miles. The constant speed drive for aircraft alternators (story on page 6) was developed for planes of this type.

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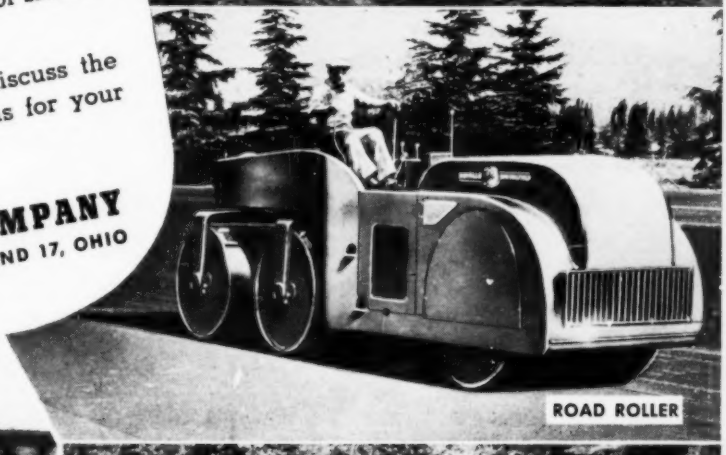

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A CONSTANT SPEED DRIVE FOR AIRCRAFT ALTERNATORS

A hydraulic device for driving a 400 cycle aircraft alternator at constant speed regardless of the engine speed to provide the electric power required by large multi-engine aircraft. The volumetric displacement of the pump, directly connected to a constant speed hydraulic motor, is controlled by the angle to which the wobbler plate is set by a control piston assembly.

By L. H. SCHUETTE and R. CHRZANOWSKI
Rockford, Ill.

THE HYDRAULIC constant speed drive described herein is a device which drives a 400 cycle aircraft alternator at constant speed. It is driven by the main aircraft engine and provides a controllable speed sufficiently constant to operate 400 cycle alternators in parallel whether the engine is idling or at takeoff speed, or at any intermediate speed required by flight conditions. Flight test experience is still somewhat limited since only three planes are using this equipment; a test B-29, the B-36 and a modified B-36. Altitudes of 40,000 feet have been reached with the drives functioning normally. Torsional vibrations from the main aircraft engines do not seem to affect the drive in any way nor is alternator operation affected.

Electrical power in the range of 60 to 120 kw is required by the larger multi-engine aircraft. Thorough investigation by the Army Air Forces and the electrical industries has indicated that the use of a 400 cycle 208/120 volt ac system appears to be capable of delivering this power. Since alternators must be driven at a substantially constant speed when parallel operation is desired, the means for driving them must be considered. The general opinion, based on the investigation, was that the lightest weight could be obtained by driving the alternators directly from the main aircraft engine. This required that some device be installed between the alternator and the main engine which would provide constant speed for the alternator while the main engine was operating throughout the entire range from idling to takeoff and overspeed conditions. Several hydraulic mechanisms are available which could be arranged to provide constant speed, e.g., hydraulic systems in combination with planetary gear trains or variable displacement hydraulic transmissions. However, considering basic aircraft requirements of minimum weight and space with maximum efficiency, a thorough study indicated that the most desirable system would be a differential type hydraulic transmission wherein only the torque represented by the difference in speed between engine and alternator is transmitted by hydraulic pumping and motoring action.

A governor is required to permit successful parallel operation of the alternators and to divide the load equally under various conditions of acceleration and load. This governor takes its speed signal from the output shaft of the drive and its load signal from the voltage and current of the alternator to position a control valve which, in turn, regulates the quantity of oil pumped to give the desired output speed.

Design Requirements

General requirements specified the use of a 400 cycle alternator rated for 30 kw at 6000 rpm. In order to allow for the alternator and exciter losses, a continuous load output rating of 50 hp was required of the alternator drive. Further requirements specified that it should be

Fig. 1. A B-29 in flight, shown with the bomb-bay doors open. The specially designed twin bomb-bays permit the plane to drop small, large or mixed size bombs.

capable of maintaining a nominal output speed of 6000 rpm over a range of input speeds from 2400 to 9000 rpm. At input speeds of less than 3600 rpm, the available power output of the drive could decrease proportionally with the decrease in input speed.

A means of providing for infinitely variable speed control had to be placed in the transmission so that the governor would permit parallel operation and proper load division between the alternators.

Under certain conditions of acceleration, load application or synchronizing disturbances, the generator acts as a motor. To prevent this motor from transmitting power in a reverse direction through the drive to the engine, a free-wheeling clutch had to be incorporated in the drive.

Since the drive was intended for aircraft, important consideration had to be given to minimum weight, minimum space requirement, high overall efficiency and the ability to operate over a wide range of temperature variations and altitude conditions.

Drive Design

Basically, the alternator drive consists of a variable displacement pump whose cylinder block is bolted directly to the cylinder block of a fixed displacement hydraulic motor. This cylinder block assembly rotates on ball bearings and is drived through fixed ratio gearing by a quill type input shaft. This shaft, in turn, takes its power from an accessory drive pad on the main aircraft engine. The variable displacement pump is of the axial piston type. Piston stroking is achieved by the biasing action of a wobble plate as the cylinder block assembly rotates. The length of the piston stroke is determined by the angle at which the wobbler plate is tilted. A control piston assembly regulates the angle to which the wobbler plate is set. The control piston actually controls the volumetric displacement of the pump by regulating pump stroke.

At 50 hp output approximately 2300 psi hydraulic pressure is developed by the pump. Oil is delivered to the direct connected hydraulic motor, also of the axial piston type. In the motor the high oil pressures force the pistons to move outwardly against a motor wobbler plate of fixed angle. The motor wobbler shaft, free to rotate on ball thrust bearings, transforms the axial piston movement into rotary motion. A gear cut into the motor wobbler shaft meshes with the output shaft of the drive. Incorporated in the output shaft is a sprag type free-wheeling clutch and the spline through which the alternator is driven.

Neither the pump nor the motor is self-priming; it is necessary that a charge oil be supplied to keep the pistons out against the wobbler plates on their return strokes. For this function, as well as to provide an adequate supply of oil for governor control, a gear type charging pump is incorporated in the alternator drive. This pump is driven through gearing by the input shaft with back pressure held by a spring-loaded relief valve. A circulating oil pump, driven by the same shaft, circulates oil through an external cooler which is necessary to dissipate power loss in the transmission. Other functions of this circu-

lating pump are to provide oil under pressure for lubricating various critical points in the drive and to pressurize the inlet to the charging pump. A tachometer drive shaft, geared to the main output shaft, supplies power for the operation of the tachometer generator from which speed control is sensed for the governor.

The entire mechanism, except for the cooler and the filter, is built into a three-section aluminum housing which provides a mounting pad for the alternator, the tachometer generator and the governor, an input shaft flange and the necessary lugs to support the drive in the installation. The dry weight of the entire mechanism is 72 pounds.

The choice of gear ratios between the input shaft and cylinder block assembly and the motor shaft and output shaft, as well as displacements of the pump and motor, was based on the desire to get maximum overall efficiencies at normal cruising speeds of the aircraft.

At maximum overdrive position, the wobbler angle is 26 degrees, giving a displacement of 2.61 cubic inches per revolution. At underdrive position, the wobbler angle is minus 4 degrees, with a displacement of 0.4 cubic inches per revolution. Displacement of the motor is constant at 1.5 cubic inches per revolution.

Operating Characteristics

Initial rotation of the input shaft starts rotation of the pump and motor cylinder block assembly, the charge oil and circulating pumps simultaneously. The circulating pump takes oil from the main reservoir in the drive and sends it through the cooler, the filter and into a pressurized sump within the drive. A back pressure is held on this pressurized sump by a spring-loaded relief valve which dumps excess oil back into the main reservoir. The charge oil pump takes oil under pressure from the pressurized sump and delivers it at 300 psi or more to the governing control and to the inlet of the main pump and motor, so that the pistons will maintain contact with the wobblers at all times and to insure a full charge of oil on their return strokes.

When the charge oil pressure is established, the main pump will start delivering oil to the motor, starting rotation of the output shaft. At the same time, the oil pressure acts through the governor valve which functions to place the unit in maximum overdrive. At this point, the output shaft and alternator are overspeeding the input shaft by a ratio of 1.5 to 1, which, after gear corrections, is the ratio between the maximum displacement of the pump to the displacement of the motor. The wobbler stays in the maximum stroke or overdrive position until the input speed has reached 2400 and the output speed is 6000 rpm.

At the minimum input speed of 2400 rpm, the drive must add 3600 rpm by hydraulic pumping and motoring action to attain the required output speed of 6000 rpm; as input speed increases, the speed difference between input and output is decreased; at 6500 rpm input speed the wobbler plate is in neutral or zero stroke position and there is no pumping action; at higher speeds the cylinder block assembly will rotate faster than the constant speed motor shaft. The alternator load will still maintain output torque of the drive in the same direction.

With an increase in input speed above 2400 rpm, the normal tendency is to further increase the output speed. At this point, the governor, set for 6000 rpm, takes over and regulates the control piston and wobbler assembly to decrease pump stroke. Less oil then flows from the pump to the motor, reducing the differential speed between motor and pump until proper output speed is attained.

The governor is a solenoid actuated pilot valve which valves oil to one side or the other of the main wobbler control piston. A three-phase tachometer generator geared to the output of the drive gives the governor speed its signal. After rectification, the tachometer current goes through the solenoid with the solenoid force reacting against a spring. At 6000 output rpm, the solenoid and spring forces are balanced, with the pilot valve in its neutral position. If for any reason the output speed should increase, a higher voltage at the tachometer generator will result, which will increase solenoid current. The extra solenoid force thus created will displace the pilot valve against the spring to valve oil to the control piston in a direction to decrease pump displacement. As the output speed is reduced, the tachometer voltage drops off until the pilot valve is again in the shut-off position. At this point the control piston stops moving, again balancing input speed, pump stroke and output speed.

A decrease in output speed below normal setting will decrease tachometer generator voltage and reduce solenoid strength. The solenoid will then be overpowered by the spring, displacing the pilot valve in the opposite direction. Control oil will then act to lengthen stroke and increase pump displacement. The motor will be driven faster until the proper balance between input speed, pump stroke and output speed is again established.

At the minimum input speed of 2400 rpm, the drive must add 3600 rpm by hydraulic pumping and motoring action to attain the required output speed of 6000 rpm.

Governor Takes Over

As the input speed is increased, the speed difference between input and output is decreased, requiring a reduction in the quantity of oil pumped to the motor. This is taken care of by the governor as it changes piston stroke by changing the angle of the wobbler plate.

At approximately 6500 input rpm the wobbler plate is in neutral or zero stroke position. No pumping action is created and no oil flows from the pump to the motor. The motor pistons cannot reciprocate and there is no relative motion between the motor shaft and the cylinder block assembly. Since the cylinder block assembly is being driven by the input shaft, the motor shaft will move at the same speed since there is no relative speed between the two. There is a pressure generated because of the load but the oil is literally locked because of the absence of pumping action.

As the input speed increases still further, the cylinder block assembly will be going faster than the motor shaft, which always operates at constant speed. Relative motion between cylinder block assembly and motor shaft will again take place but in a reverse direction since it is now necessary to subtract speed from the input rather than add it to maintain proper output speed. The alternator load will still maintain output torque of the drive in the same direction. Because of the change in differential speed of the hydraulic mechanism, the motor wobbler shaft now rotates relative to the cylinder block in the same direction as the load torque applied to the shaft. When a device rotates in the same direction as the torque applied to its shaft, it is specifically a pump, or in electrical analogy, a generator.

A similar explanation applied to the pump end shows that the torque applied to wobbler trunnions is in a direction opposite to the relative motion between the wobbler and cylinder block assembly. This specifically, is now motor action.

Therefore, it follows that when input speed is higher than output speed or, put another way, when input torque is less than output torque, the motor becomes a pump and the pump becomes a motor. This is known is the underdrive condition.

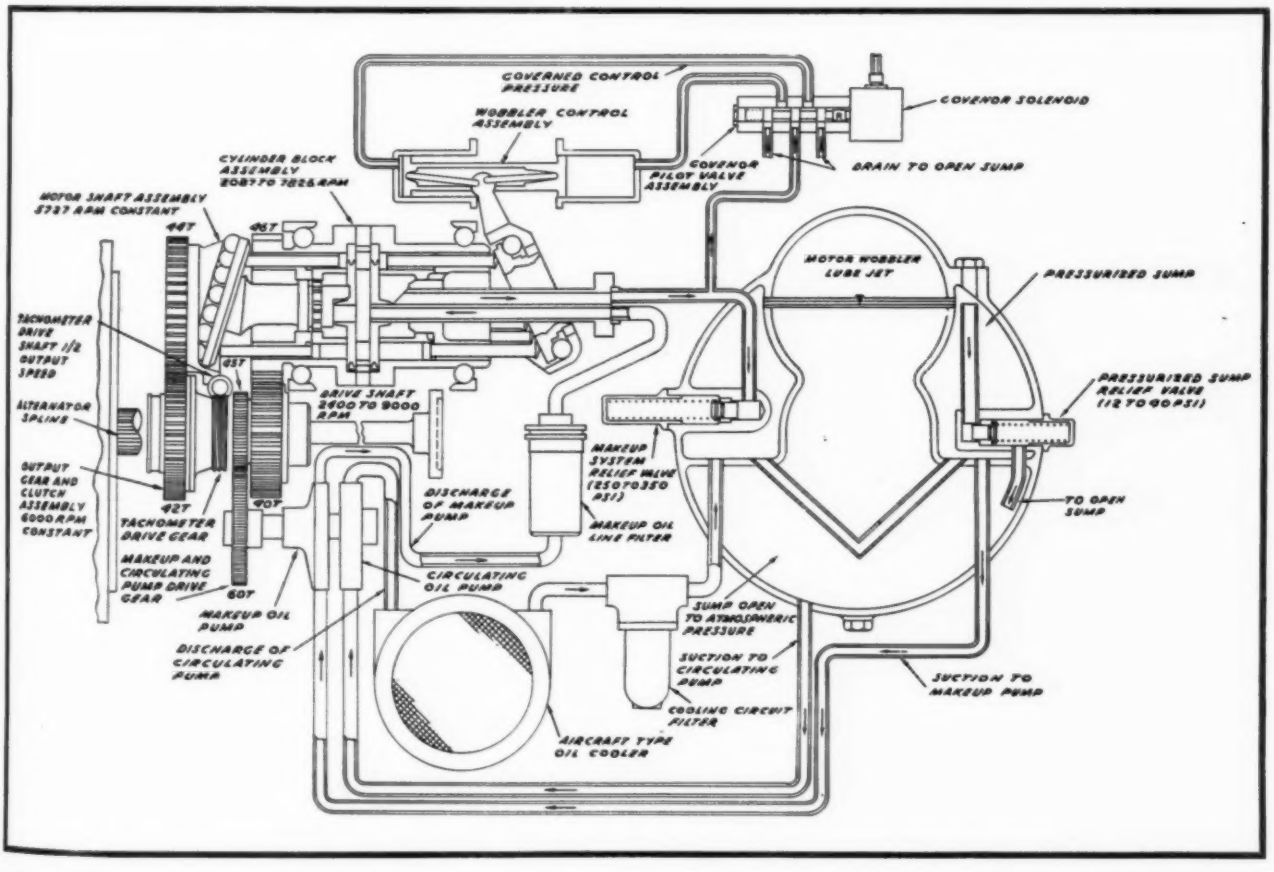
Whether in overdrive or underdrive, the pump wobbler can do no useful work since it does not rotate. Its sole function is to maintain torque equilibrium between input and output shafts and it does not enter into considerations of power input or output.

The flow of oil from the motor to the pump is handled by the pump wobbler moving into a negative angle and allowing the pump pistons to stroke at a rate sufficient to maintain constant output speed. The stroke, or displacement, is a direct function of the relative speed between pump wobbler and cylinder block assembly and the pressure is a function of torque which the pump has to maintain.

The principal power losses in the drive occur in pumping the charge oil, pumping the circulating oil through the external

(Continued on Page 22)

Fig. 2. Schematic view of the alternator drive.


GOVERNED CONTROL PRESSURE
WOBBLER CONTROL ASSEMBLY
GOVENOR SOLENOID
GOVENOR PILOT VALVE ASSEMBLY
DRAIN TO OPEN SUMP
CYLINDER BLOCK ASSEMBLY 6087 TO 7825 RPM
MOTOR SHAFT ASSEMBLY 5737 RPM CONSTANT
MOTOR WOBBLER LUBE JET
PRESSURIZED SUMP
TACHOMETER DRIVE SHAFT 1/2 OUTPUT SPEED
PRESSURIZED SUMP RELIEF VALVE (12 TO 90 PSI)
ALTERNATOR SPLINE
DRIVE SHAFT 2400 TO 9000 RPM
MAKEUP SYSTEM RELIEF VALVE (250 TO 350 PSI)
OUTPUT GEAR AND CLUTCH ASSEMBLY 6000 RPM CONSTANT
TO OPEN SUMP
DISCHARGE OF MAKEUP PUMP
MAKEUP OIL LINE FILTER
TACHOMETER DRIVE GEAR
MAKEUP AND CIRCULATING PUMP DRIVE GEAR
CIRCULATING OIL PUMP
SUMP OPEN TO ATMOSPHERIC PRESSURE
MAKEUP OIL PUMP
DISCHARGE OF CIRCULATING PUMP
SUCTION TO CIRCULATING PUMP
SUCTION TO MAKEUP PUMP
COOLING CIRCUIT FILTER
AIRCRAFT TYPE OIL COOLER

COUPLING OR TORQUE CONVERTER?

The characteristics which distinguish the hydraulic coupling and the hydraulic torque converter are discussed as well as their common advantages as fluid power drives. The advantages and limitations of both coupling and converter are cited by established uses and suggest the wide ranges of applications for which these drives are suited.

THERE SEEMS to be a good deal of confusion between hydraulic couplings and hydraulic torque converters. Since a clear understanding of the characteristics of these units is essential if they are to be used in types of applications for which they are each suited, it may be well to examine the basic designs and operation of these two units.

While the two units may be best understood by an analysis of the differences between the units, it must be remembered that the basic power principle is the same—neither has a rigid connection between driving and driven members; the power is entirely transmitted by fluid mass and velocity. In both units the hydraulic connection acts as a cushion against shock loads and torsional variations.

First, it is important that the basic idea of torque be kept clearly in mind. Torque may be technically defined in several ways. However, fundamentally it is the force which produces or tends to produce rotation or torsion. In terms of the units under discussion, torque is the lever that moves the load. A light load can be moved rapidly with a short lever, but for a heavy load it is necessary to use a long lever and move the load more slowly. A hydraulic coupling offers the machine operator only one lever of fixed length; whereas, the torque converter gives him a telescoping lever which automatically extends itself so that he can always move the load at the highest possible speed.

The Coupling

The hydraulic coupling is an oil pressure actuated device for power transmission in which the output torque is always equal to input torque. In general, the coupling is suited for drives in which torque and speed requirements remain fairly constant. Couplings may be operated with the power source on either side, providing rotation in either direction with practically equal efficiency.

Couplings are extremely simple in principle and design. A coupling consists essentially of two vaned members: (1) the impeller or driving member; and (2) the runner or driven member (Figure 1). The engine delivers power to the impeller which pumps the hydraulic fluid against the runner, setting it in motion. Blades of both impeller and runner are straight and on radial lines. This permits either impeller or runner to act as the input member. This ability to transmit power from either side of the coupling is an important advantage in mounting and installation.

Mechanically the coupling is a simple full power transmission device for breaking the solid connection between the power source and the driven equipment. Power is entirely transmitted by kinetic energy —the mass and velocity of moving oil. The rotating impeller blades throw a continuous stream of oil against the blades of the runner. Power is dedelivered directly to the output shaft. Shock loads from the driven side are smoothed out and cannot reach the engine or motor. Since the shock wave never strikes solid resistance, elements of the driven mechanism, e.g., gears, belts and cables, are protected against a sudden damaging blow or strain. Torsional vibration from the unit being driven—pump, compressor or engine—is effectively damped out, resulting in a smooth, even power flow.

Coupling design varies considerably to meet specific load or operating conditions. Areas of the oil passageways are designed to produce maximum capacity with minimum slip under anticipated running conditions without adding to the starting or drag torque which

it is desirable to maintain at the lowest point at very low speed. Extreme variations in load requirements and in ambient temperatures also must be considered in design.

Coupling Applications

Hydraulic couplings are suited to a wide range of applications. Perhaps the most important industrial use is with internal combustion engines and electric motor drives. Couplings make possible a flexibility in operation and provide an answer to the problems of inadequate torque or excessive current consumption at starting speeds.

One leading manufacturer of couplings summarizes the advantages of their use in these applications as follows:

(1) Couplings add to the service life of the entire equipment with which they are used by eliminating shock loads, torsional vibration and excessive strains of all kinds, thus assuring smooth operation.

(2) They allow the engine or motor to develop sufficient rpm for highest torque regardless of load rpm, making possible the delivery of full torque at all output speeds.

(3) They prevent stalling of engine or motor.

(4) They make unnecessary the use of oversize power units, whose excess capacity beyond actual running requirements is to take care of momentary starting demands.

(5) They eliminate mechanical expedients, such as shear pins, otherwise used to protect driven parts.

(6) They simplify remote or automatic control.

Couplings can be applied successfully to pump drives and to air compressors. They are widely used in power shovels and in other earth moving and material handling equipment, cranes and hoists, mining machinery and presses. In the oil field, the marine field, and in pump drives, where the prime mover operates at fairly constant speed with uniform torque requirements, hydraulic couplings have been very successful. This has been particularly true of multiple engine drives where the coupling simplifies the distribution of load on the engines.

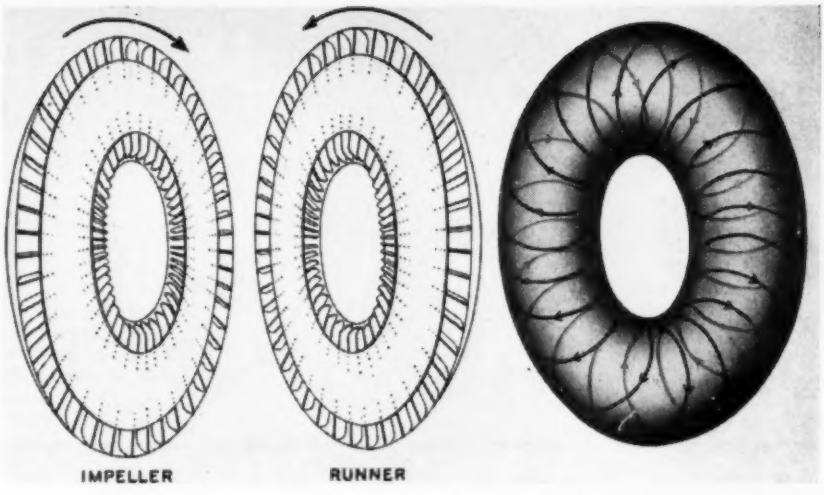
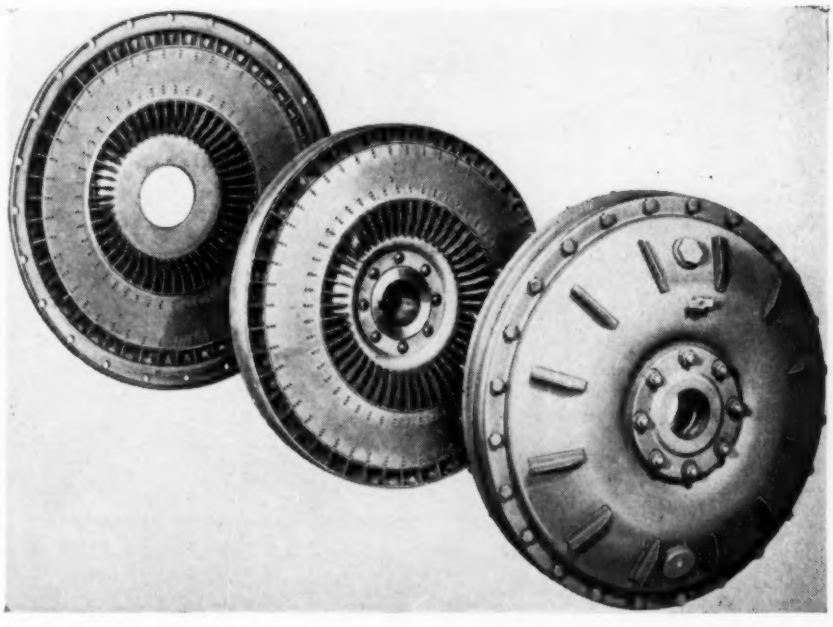


Fig. 1. The basic principle of the hydraulic coupling. As the impeller is driven by the power source, the hydraulic fluid flows from the blades of the impeller at high velocity in a curved spiral to the runner. Output torque always equals input torque.

The Torque Converter

The hydraulic torque converter is an oil pressure actuated device for power transmission for conditions of variable torque and speed and in which increased torque is required at reduced output

Fig. 2. In this typical coupling the two housing members (left and right) form a twin impeller. The runner (center) has blades on both sides to receive and pass on the force of the actuating fluid. All blades are straight and on radial lines.



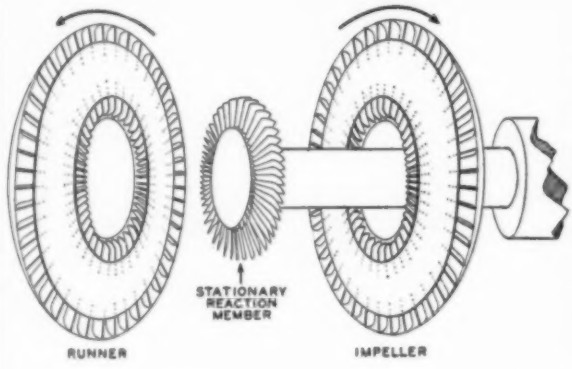


Fig. 3. The basic principle of the torque converter. A stationary reaction member is the essential part added to the parts of a coupling. The reaction member blades turn the direction of the high velocity fluid flow. This force supplements the force transferred from the impeller to the runner, imparting an output torque greater than that at the input shaft.

speeds. The torque converter, in addition to all the advantages of the hydraulic coupling, provides torque multiplication. This is not true of all types of torque converters but it is true of the type discussed here. Further, the torque converter automatically selects and transmits the proper output torque and speed for any given load within its working range. The converter provides an infinite number of output torque or speed ratios, including zero at which the output shaft is motionless at any speed of the input shaft. The balance of output torque to speed is accomplished without any change in the relationship of parts, except for the speed difference between input and output shafts. The converter output shaft always operates at the highest speed at which the load can be pulled, automatically adjusting to variations in load.

The hydraulic torque converter consists essentially of three members: (1) impeller pump; (2) runner turbine; and (3) a reaction member. The reaction member is the key to the difference between the converter and the coupling. In the torque converter (see Figure 3) the fluid is pumped by the impeller against the blades of the runner as in the coupling. Stationary reaction or guide blades incorporated in the housing are set so that in the three stage turbine (Lysholm-Smith type)[1] there is a set of reaction blades between each set of revolving runner blades. In operation, the impeller or pump, directly mounted on the shaft, draws fluid into the opening surrounding the hub and ejects fluid from its periphery at high velocity. The first runner ring of blades completely surrounds the impeller and receives the full impact of the high velocity of the fluid.

As the fluid leaves the first runner or turbine stage it is turned by the housing and brought to bear against the first set of reaction blades. These blades turn the direction of the fluid flow. The force of the moving fluid on the stationary reaction blades produces an increase in the torque released by the fluid. In other words, input torque is multiplied. From the first set of reaction blades the fluid is directed to the second set of runners or turbine stage. Fluid flow is repeated through the second runner and second set of reaction blades with another change in direction of fluid flow to the blades of the third runner or turbine stage. From the third runner the fluid completes its flow circuit by entering the impeller near the hub.

A small auxiliary pump driven from the input shaft, maintains proper operating pressure on the fluid within the housing to prevent cavitation at both impeller and runner or turbine blades.

The torque converter is established in a number of indus-

(Continued on Page 22)

[1]The other basic torque converter, the Schneider, was described in APPLIED HYDRAULICS, May, 1948, pp 6-9, 18.

Fig. 4. A typical three stage torque converter. The impeller (left) is the pump, mounted directly on the input shaft. The runner or turbine blades (center) are constructed so that the first set of blades completely surrounds the impeller. The stationary reaction blades (right) are built into the housing.

AIR CIRCUITS FOR PRESS CONTROL

By W. J. SCHUPNER
Design Engineer
Chicago, Ill.

EACH of the three control circuits shown and described has a particular feature which makes it adaptable to certain press applications, especially in die forming, riveting and in punch press work. In all modern plants primary attention is being given to safety devices and controls which permit maximum protection to the operator.

In press work one of the most common types of safety controls is the provision of two starting buttons or levers, located one on either side of the press, which must be pressed simultaneously to initiate a cycle. This ties up both of the operator's hands and eliminates the danger of accidents that might otherwise result if he had one hand free. Normally, such controls are connected in series and with proper supervision and a conscientious operator, presses so controlled are probably safe enough. However, there have been isolated instances where one pushbut-

DOUBLE PUSHBUTTON CONTROL WITH SAFETY INTERLOCK

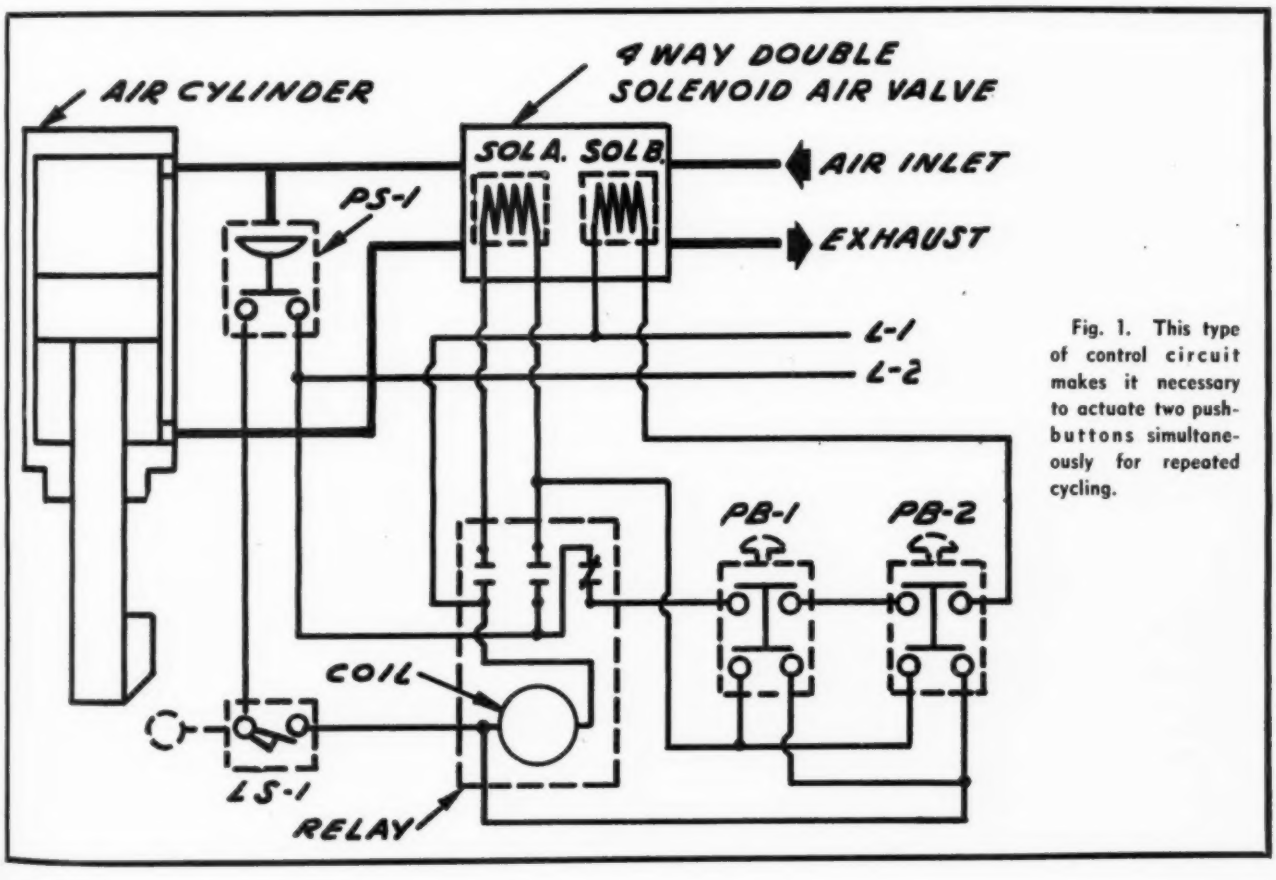


Fig. 1. This type of control circuit makes it necessary to actuate two pushbuttons simultaneously for repeated cycling.

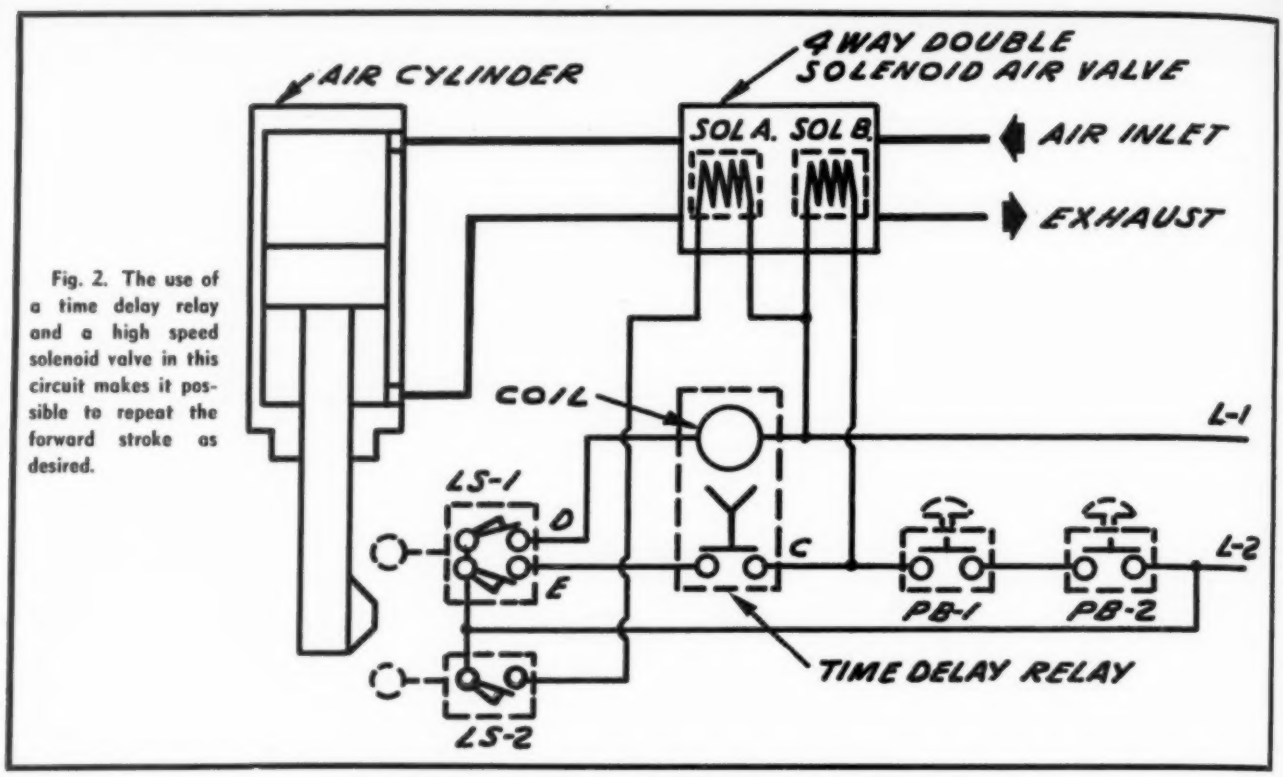


Fig. 2. The use of a time delay relay and a high speed solenoid valve in this circuit makes it possible to repeat the forward stroke as desired.

CONTROL FOR REPEATING LAST PART OF PISTON STROKE

ton has been tied down, enabling the machine to be operated with one hand with disastrous results.

Double Control With Safety Interlock

The first circuit, Figure 1, has been designed with the view of preventing this possibiiity and the machine becomes inoperative unless both hands are used. It is shown as used on a riveting machine and functions in the following manner:

Pushbuttons PB-1 and PB-2 are pushed simultaneously. These buttons have two normally open circuits each, the top circuits acting to energize solenoid "B" directly through the normally closed contact of the relay, and the four-way valve directs the piston down. As it nears the end of its stroke, a dog on the rod holds limit switch LS-1 closed, thus cutting the pressure switch PS-1 into the circuit. When the proper tonnage has been reached, PS-1 closes, energizing the coil of the relay which closes the circuit to solenoid "A" and the valve is reversed. If either PB-1 or PB-2 is tied down, the piston will go through only one cycle since the lower contacts of either pushbutton now act to maintain a holding circuit in the coil and the normally closed contact of the relay is open. This makes it impossible to energize solenoid "B" to start the piston down again until both pushbuttons are released.

Partial Cycle Repeating

The circuit shown in Figure 2 was developed for the die forming of a product which required that the last inch of the stroke be repeated—in this case only once, but it may be repeated any number of times depending on the cycle setting of the time delay relay. Operation is as follows:

Press down PB-1 and PB-2, which are connected in series with and also energize solenoid "B". Piston starts down. LS-1 is a spring centered limit switch with two normally open monetary contacts, one set of which closes on the down movement of the lever arm and the other on the up movement. The dog on the piston rod trips and by-passes LS-1, closing contact "D" which energizes the coil of the relay, which in turn closes contact "C". The opening action of contact "C" is retarded pneumatically to a predetermined time setting — less than a second. When the dog closes LS-2, solenoid "A" is energized, directing the piston up. The dog strikes LS-1 again, closing contact "E", which energizes solenoid "B", immediately reversing it. LS-2 causes it to move up again. This time it strikes and bypasses LS-1; the closing of contact "E" is ineffective since it has been timed out by the relay and piston continues to the top of the stroke. The action here is very fast and requires a high speed solenoid valve.

Air Operated Automatic Cycling

The sequence of operations in the riveting cycle shown in Figure 3 is very similar to that in Figure 1, except that the cycle is all air operated. PV-1 and PV-2 are standard spring return three-way pilot valves, cam operated. The four-way master valve is a standard

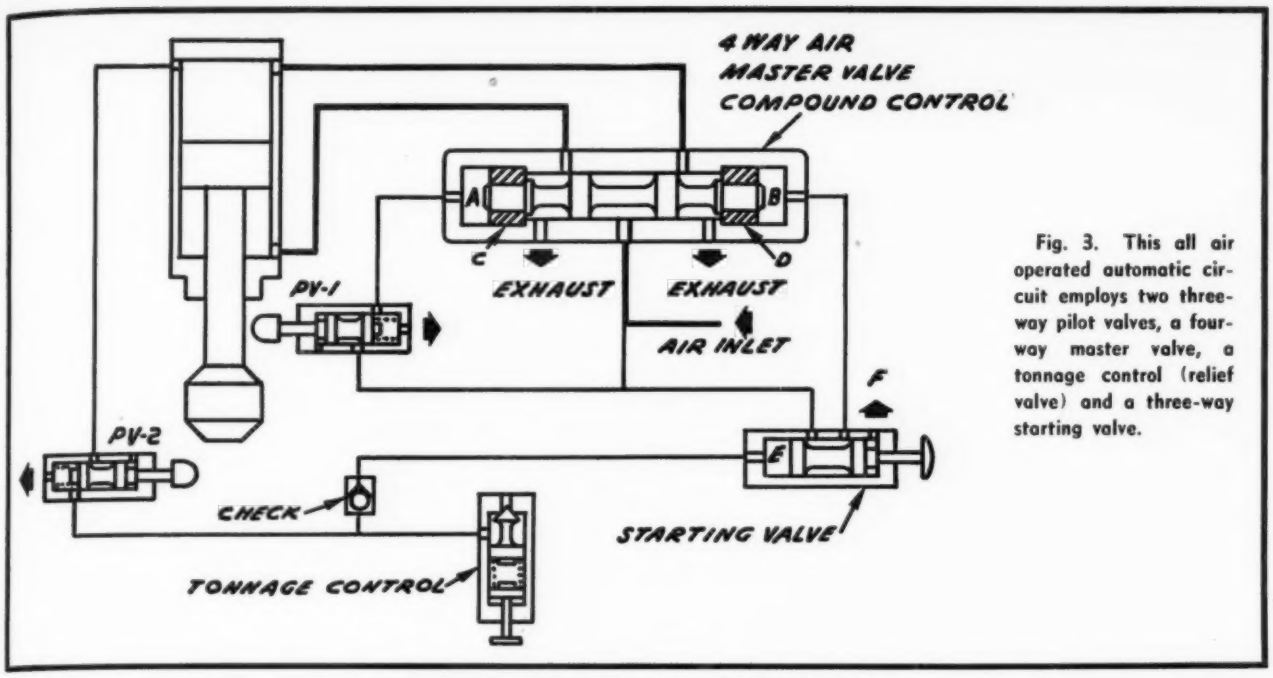


Fig. 3. This all air operated automatic circuit employs two three-way pilot valves, a four-way master valve, a tonnage control (relief valve) and a three-way starting valve.

AIR CONTROLLED AUTOMATIC RIVETING CYCLE

valve and opens both cylinder ports to exhaust in the neutral position. The tonnage control is a spring loaded relief valve; the three-way starting valve may be either hand or foot operated with slight modifications from standard.

At rest position the piston is all the way up and the spool in PV-1 is held to the right against a spring by a cam on the rod. Air pressure is maintained in chambers "A" and "B" of the master valve which holds it in neutral through PV-1 and the starting valve.

To start the cycle, push in knob on the starting valve. Air in chamber "E" is exhausted to atmosphere through the check valve and PV-2. Air in chamber "B" bleeds off at "F". Pressure at "A" acts on the end of the spool and forces it to the right. Piston "D" moves with it but "C" remains stationary. Air is now admitted to the back of the cylinder, starting the piston movement down. As it moves down, chamber "A" is open to atmosphere through PV-1. At the lower end of the piston stroke a cam on the rod holds spool in PV-2 to the left, admitting air at line pressure into the tonnage control valve and against the check valve. When a predetermined piston loading has been reached, poppet in the tonnage valve lifts off its seat and air enters chamber "E", returning the spool in the starting valve to its original position.

Air now enters master valve at "B", moves piston "D" to the left against its stop and and spool and piston "C" all the way to the left; air in chamber "A" being exhausted to atmosphere through PV-1. This action puts air in the lower end of the cylinder and the piston moves up. The cam on the rod forces the spool in PV-1 to the right, admitting air again to chamber "A". However, since the area of piston "C" is greater than that of the end of the spool, piston "C" will move to the right against its stop, returning the master valve to neutral. A feature of this particular circuit is that, although the cycle is automatic, the piston may be returned at any point in the forward stroke by reversing the starting valve.

In the August issue of APPLIED HYDRAULICS the following outstanding articles will appear:

"Hydraulic Circuits in Guided Missiles"
by E. H. Buller and Lt. B. H. Ford, Air Materiel Command, United States Air Force

"Non-Pressurized-in-Flight Hydraulic System"
by Harry Kupiec, Air Associates, Inc.

"Design Factors in High Production Machines"
by Carroll R. Alden, Ex-Cell-O Corp.

We expect to include the first of a series of six articles on the maintenance of hydraulic systems and an article by M. M. Seeloff, The Taylor-Winfield Corporation, on the hydraulic controls of their welding equipment.

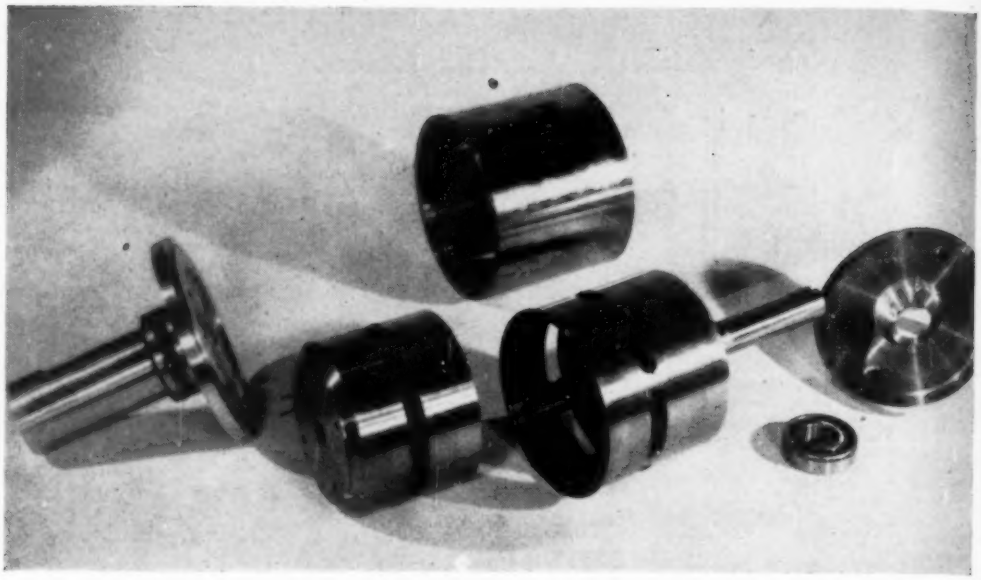


Fig. 1. Magnetic fluid clutch of the type suitable for use in automobiles and machinery. Exploded view shows principle components.

THE MAGNETIC FLUID CLUTCH

A new, highly efficient type of magnetic fluid clutch, stable for a wide range of speeds, that offers unusual advantages for the automotive and servomechanism fields and for the control of automatic machines.

A NEW TYPE of magnetic fluid clutch has been developed at the National Bureau of standards by Jacob Rabinow, Chief of the Ordnance Mechanics Section. The development of this clutch was based on the discovery that frictional forces between solid surfaces separated by certain fluid media can be controlled by magnetic fields. Experimental work has shown that high efficiency, smooth operation, long life and simplicity of construction make this clutch design particularly adaptable to servomechanisms, automatic machinery control, automotive service and other fields where ease of control and stability from low to very high speeds are important.

There are numerous types of mechanical and electro-mechanical couplings employed for continuous control of torque. In all these coupling devices slippage is employed to dissipate desired portions of power. The four most commonly used types are: the mechanical friction type; the fluid coupling type; the electromagnetic type; and the electrostatic type.

The mechanical dry friction clutch, the best known, is used on practically all automobiles. Friction plates of dissimilar material are made to press against each other, coupling a driving shaft to a driven shaft. However, such clutches are not suitable where continuous slippage is desired. The principal disadvantages are rapid wear, non-uniformity of results and overheating.

The fluid coupling is superior where smooth slippage is important. While this type of coupling has many advantages it is extremely difficult to control by external means, particularly where high speed of control is required. Since the fluid coupling cannot be locked effectively, there is always an energy loss.

The electromagnetic clutch is a device in which the driving member contains one part of the magnetic circuit and the driven member contains iron to complete the magnetic circuit. This type of clutch is extremely rapid in operation, rel-

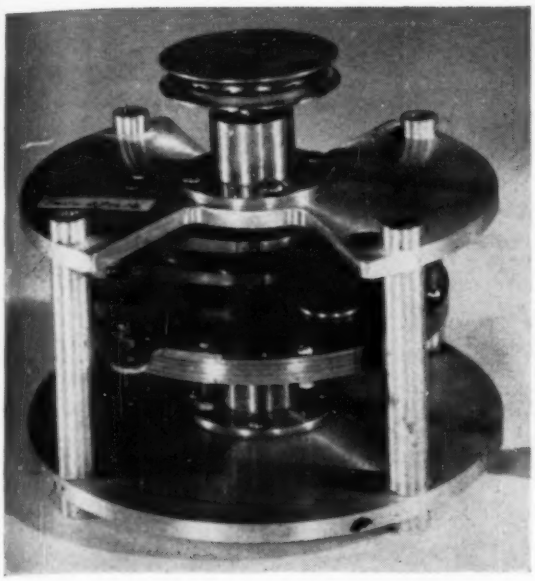


Fig. 2. The first test model of a practical magnetic fluid clutch. Slip rings energize a coil in the central chamber; the fluid media is magnetized locking the plates together.

atively simple in construction and easily controllable. However, difficulties in wear, lack of smothness and heat dissipation limit its usefulness.

The electrostatic clutch, used almost entirely for extremely high-speed operation, utilizes electrostatic attraction between very closely spaced surfaces to achieve the same results accomplished by use of the magnetic field in the magnetic clutch. This clutch requires high voltages but can be operated at extremely high speeds and with very low control power.

Basic Principle

The magnetic fluid clutch operates on the following principle. When the space between two parallel magnetic surfaces is filled with finely divided magnetic particles and a magnetic field is established between the plates, the particles form chains which bind the two plates together as if they were held by clamps.

The magnetic particles may be finely divided iron which, for most applications, are mixed with a liquid such as oil to prevent packing and to afford smoother operation of the clutch.

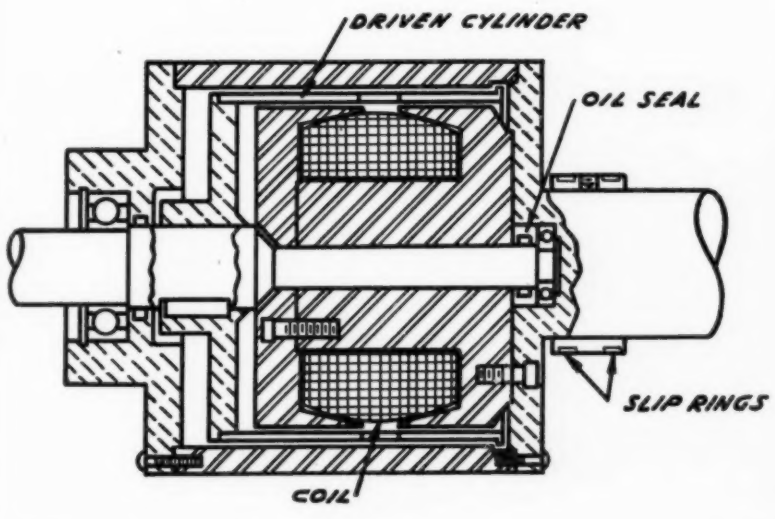
Since the bond between the plates is a function of the gradual increase of the magnetic field, and the amounts of electric power required are small, it is a simple matter to interlock the electric circuits of the clutch energizer to speed, throttle setting and power demands of an automotive vehicle or of a servomechanism.

A magnetic clutch of the simplest type consists of a driving shaft and plate, a driven shaft and plate and fine iron particles suspended in oil packed between the plates. The design used at the Bureau of Standards has a fixed gap between plates and was of the type shown in Figure 2. The bearings are external to the oil mixture and, because a vertical shaft was used, oil seals and their friction are eliminated.

Sealing the oil-iron mixture in its compartment presents a special problem. There are two places where such sealing is generally required: the point where the shaft supporting the internal member leaves the assembly; and, if an internal coil is used, the point at which the leads are brought out. Good results have been obtained using "O" rings at the shaft bearings. Other types of packings can doubtless be employed with good results. If there is any danger of iron particles getting into ball bearings, it would be desirable to add a magnetic trap beyond the oil seal to trap any particles of iron which might get through. The oil that passes this point would then be clean of any iron particles. Where seals present difficulties, e.g., in the case of very thin shafts, the coils can be placed on the outside of the friction surfaces.

It is also possible to make the energizing coil completely separate from the clutch; the the coil is not revolved, but transmits the magnetic force to

Fig. 3. A special design, with very thin driven member, for use on high speed servomechanisms. The exciting coil is a part of the driving member.



the working faces through short air gaps. This can be accomplished at some loss of efficiency but is suitable for small sizes.

For different types of service multiple plate clutches can be designed with the sets of plates either in series or in parallel. The use of gaps in parallel requires large amounts of iron particles; the use of gaps in series reduces the amount of iron particles needed but increases the excitation needed to bridge the gap between the plates. The choice of setup thus depends on availability of power and considerations of weight and size of unit permissible.

In high speed servo work, where low inertia is required in the driven member, it is desirable to make the exciting coil and the magnetic iron a part of the driven member. Only a very thin member is then needed to pick up the torque in this type, as shown in Figure 3.

The original test model was later modified and used to investigate the effect of plate gap on torque. Using a mixture of 9 parts of carbonyl E iron and one part of oil by weight, the following torques were produced: 2.5 lb–in with .062 in gap; 3.0 lb–in with .025 in gap; 3.5 lb–in with 0.012 in gap. These torques were obtained at low speeds; for the effect of speed and gap length on torque, see Figure 4.

Experiments showed that the nature of the fluid used had no effect on the performance;

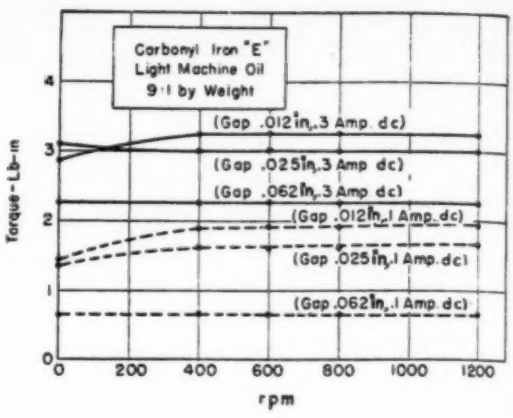


Fig. 4. Torque for various gaps on a 1 x 1¼ in cylinder clutch.

hence, it would undoubtedly be possible to employ silicone fluids that would enable the clutch to operate at extremely high and low temperatures, a consideration of great importance in some industrial and in military applications. Different combinations of fluids and iron particles were tested and it was found that in this particular clutch a mixture of carbonyl E iron of 8 microns average size and oil gave the best results. Dry powder was also tried; torques of the same magnitude were obtained but eccentricity and misalignment of plates produces erratic operation.

This new type of magnetic fluid clutch is expected to find its main application in the field of servomechanisms. Friction clutches have been used for this type of work, but their lack of smoothness, changes in characteristics due to wear and their non-linearity have resulted in unsatisfactory operation. The new clutch should solve such problems.

While servomechanisms can be operated at variable speed motors, hydraulic transmissions and by many other means, clutches and brakes have the advantage of low inertia-to-torque ratios.

Magnetic fluid clutches are particularly adaptable as the final elements of electro-mechanical amplifiers. Other possible fields of application are as constant - torque and overload devices in which the clutch need never be de-energized—permanent magnet clutches would be particularly useful for this work. These clutches are also expected to be useful in automatic machinery control where servomechanisms are not used; in drilling and tapping operations and in overload devices.

In addition to ease of control, high efficiency and smooth operation, the fluid clutch is very simple to construct — it consists basically of driving plate, driven plate and separating fluid media. This simplicity of design plus negligible wear factors and a practical identity of static and kinetic friction and high mechanical efficiency — 100 percent when the load is below the slipping torque—makes possible a clutch with extremely long life. All of these characteristics combine to assure ease of manufacture, installation and operation, all important factors in the application of the magnetic fluid clutch to industry.

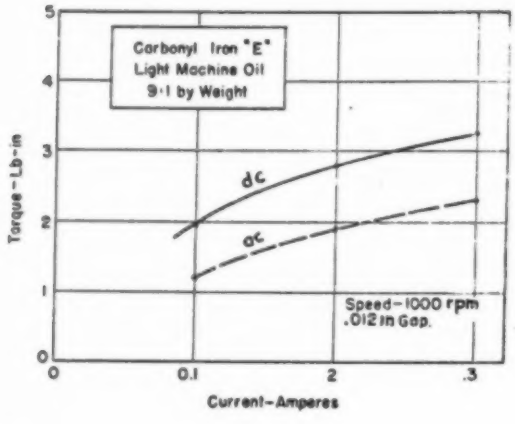


Fig. 5. Torques using ac and dc current on a 1 x 1¼ in cylinder clutch.

LETTERS to the Editor

I have clipped for a notebook sheets A-1 and A-2 of your reference material from APPLIED HYDRAULICS. In mounting this I punched the top of the title page. When turning to the back of the first page I find that it is necessary to reverse the notebook. I would like to suggest that inasmuch as these sheets are apparently designed for notebook mounting that the printing of the second page be reversed so that it can be read by merely turning the sheet without the necessity of rotating the book in which it is mounted.
This comment would also apply to reading material even when it has not been clipped from the magazine.

R.Q.S.

Whatever happened to the Hydraulic Code that GM was working on and that was scheduled to be released this spring? Were nomenclature and drawing symbols included?

G.N.R.

Are all-hydraulic automobiles around the corner? With torque converters, fluid drives of several sorts, hydraulic starters, hydraulically operated windows and seats, cooling fans and brakes already in the picture, why isn't an entirely hydraulic automobile practical?

F.D.E.

EDITOR'S NOTE: How are you going to provide ignition?

We are in the process of buying several major production machines. I like the advantages of hydraulics and so does our chief engineer but we hesitate about hydraulic machines because our maintenance department has had no experience with this type of drive and control. Where can we send one or two maintenance men to give them a grounding in hydraulic maintenance?

A.J.

I do not follow the claims of a manufacturer who states that a sleeve in a fitting hardened to 45 Rc can be shrunk by drawing up the nut. As far as I understand the metallurgy involved, there are a number of things that could happen to the tube but "shrinking" chrome moly steel is something else again.

J.T.

Could you suggest a good engineering text covering the design and installation of hydraulic systems?

A.W.L.

This column is open to comments on general trade and technical problems. Readers' questions and answers will appear regularly—EDITOR.

FORD PROGRAM FOR HYDRAULIC MAINTENANCE

By GEORGE D. FENSKE

SOME MONTHS AGO the management of the Ford Motor Company requested the Training Department to assist a committee of interested departments in drafting a manual for hydraulic maintenance. Personnel of the Production Engineering department, the Purchasing Engineering department, Hydraulic Maintenance supervisors, Hydraulic Maintenance and Industrial Conservation Committee were invited to attend.

After considerable discussion, the Committee decided that it was necessary to set up specifications for hydraulic oil. One purpose is to set a goal to which the condition of oil is to be maintained, another is to require the manufacturers of industrial equipment to designate by specifications rather than brand oils that should be used in the hydraulic system.

This led to the setting up of the Ford Motor Company Standards on Hydraulics since at this time hydraulic personnel of the Ford Motor Company had not been called upon to attend and contribute to the General Motors Joint Industry Conference on Hydraulic Standards for Industrial Equipment. The specifications were set up by advice from the Chemical Engineering department, by gathering information from technical literature of oil manufacturers and the experience of members.

With this goal in mind, the Committee formulated standard procedures and practices for the concerned plant personnel. This called for the identification of the oil and the handling equipment to prevent contamination and the mixing of oils of different viscosity ratings and the recommendations of specific oils for given equipment. Standards were made to control the temperature of the oil, to salvage the drained oil, and to clean the hydraulic systems.

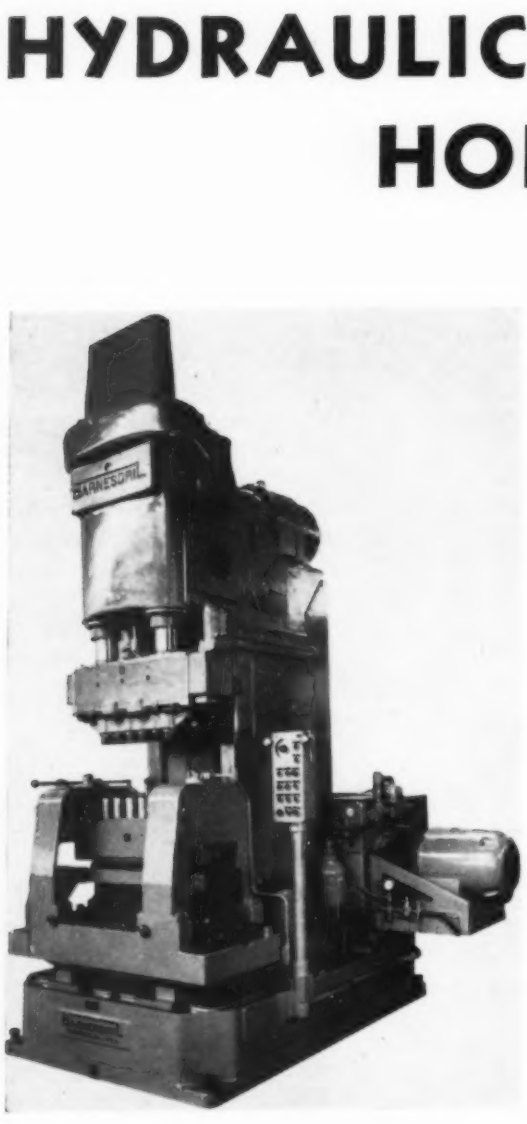
About the time the work on oil was completed, members of the Committee attended the Joint Industry Conference held at the Ford Motor Company. Participating members received the industry standards as drawn up to that date and the revised copies.

When the revised copies were received it was apparent that tremendous strides had been taken in the right direction. However, it was also realized that a great deal of work remained to be accomplished. Some of the standards, for example, were very general. Therefore, it was decided to make amendments to the industry standards to be known as Ford Motor Company's amendments to the industry standards. These amendments specify details which will reduce the overall burden of maintenance. The primary purpose of these standards or other standards is to collectively inform the builders of industrial hydraulic equipment what the users want.

The drafting of the amendments and the standard procedures and practices for pumps, cylinders, motors, control units, piping, reservoirs and accessory equipment is being carried out in a similar manner. In order to facilitate the execution of the standard procedures and practices, the Committee concluded that it was necessary to present an answer to some of the problems by a project proposal.

At the present time, the Committee is standing by until the present proposal is processed.

APPLICATION OF HYDRAULIC EQUIPMENT TO HONING MACHINES



The use of a two pump hydraulic circuit to actuate the movements of a vertical honing machine. One pump is used to drive the hone reciprocating cylinder —the other, with its oil delivery divided, operates a clamping fixture, charges an accumulator, operates a spindle engagement clutch cylinder and expands and collapses the hones.

Fig. 1. The front view of the six-spindle vertical honing machine. The motor driven metering pump, relief valve and accumulator are shown at the right rear of the machine.

By EARNEST Y. SEBORG
Hydraulic Engineer
Barnes Drill Co.
Rockford, Ill.

THE HONING PROCESS employs the use of bonded abrasive sticks which are brought into contact with the metal in varied direction of motion to remove metal in shear. Honing is the most practical means of accomplishing close limits in dimensions as well as in surface contour. This is particularly true of internal and external cylindrical surfaces.

This article deals with the machines used to hone internal cylindrical surfaces and with the operation of their hydraulic and air circuits. The honing operation is accomplished by rotating and reciprocating a multi-stick tool within the cylinder. The tool is expanded to maintain contact with the cylinder wall with sufficient force to cause the abrasive particles of the bonded stone to cut.

The honing machine shown in Figure 1 is a six-spindle machine for simultaneously honing the bores of a six cylinder automobile engine. The machine illustrated is the No. 320 honing machine made by the Barnes Drill Co.

The machine spindles are rotated by means of an electric motor through a gear train and a hydraulically operated clutch. The clutch is engaged and disengaged each cycle to start and stop spindle rotation. When disengaged, the clutch acts as a brake to stop the spindles. The spindle head is reciprocated vertically on two rams by means of a hydraulic cylinder

and piston mounted between the rams. This head is counterbalanced by means of an air cylinder. The electric motor and hydraulic pump for furnishing the fluid power are mounted on a tank assembly on the rear of the machine. A separate motor driven pump is used to deliver cutting coolant to the hones. The coolant is turned on and off automatically after each cycle.

The cylinder block is located and clamped hydraulically by means of a holding fixture which operates off of the main hydraulic system.

The honing tools are expanded by taper wedges operated by push rods inside the tool assemblies; the assemblies in turn are operated by a rack and pinion. This rack is actuated by the cylinder assembly mounted on the reciprocating head. These cylinders also are powered from the main hydraulic system. Figure 2 is a diagram of the hydraulic circuit. The motor drives two pumps in tandem on the same shaft. The larger of these pumps, a balanced vane rotary type (1) delivers oil through panel (5) to the hone reciprocating cylinder. This panel contains a relief valve, a pilot four-way valve and a pilot operated four-way valve. The pilot valve is operated by the reciprocating head through the control dial, a cam

(Continued on Page 28)

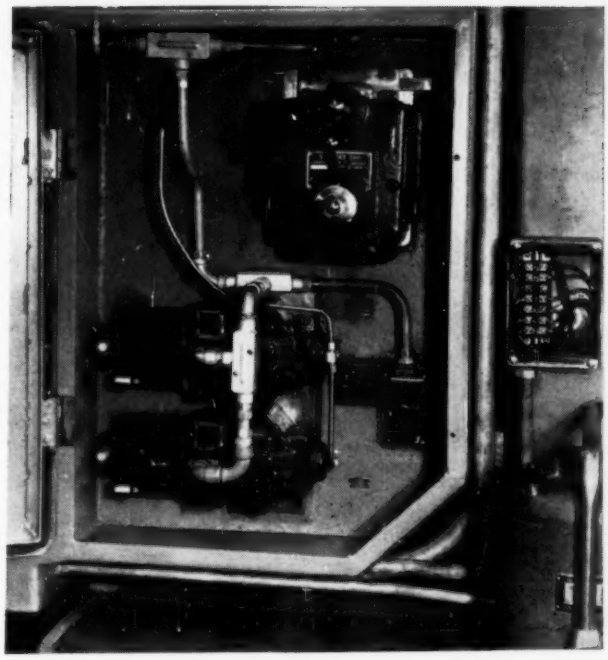
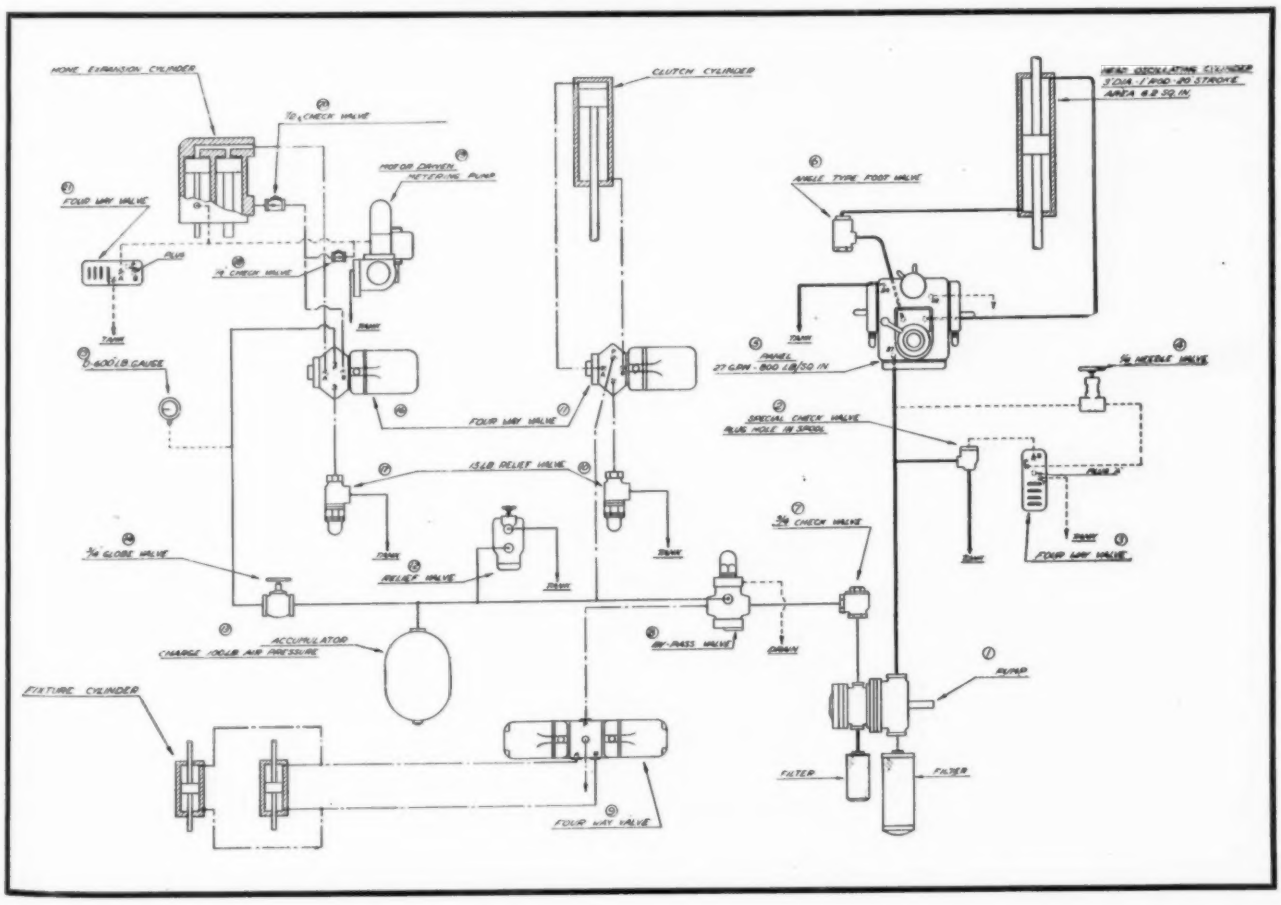


Fig. 2. Control panel showing reciprocating cycle panel, solenoid four-way valves for operation of clutch cylinder and hone expansion cylinders (left) and solenoid four-way valve for the reciprocating cylinder.

Fig. 3. Diagram of the hydraulic circuit.



A CONSTANT SPEED DRIVE FOR AIRCRAFT ALTERNATORS

(Continued from Page 9)

circuit, bearing friction, gears and leakage of the high pressure oil in the hydraulic circuit.

Performance

Maximum overall efficiency is reached between 4500 and 5500 input rpm and measures 88 percent at full load. As input speed increases, bearing friction losses increase considerably so that at 9000 rpm the overall efficiency drops to 75 percent.

Depending on input speed, between 2 and 8 gallons of oil per minute are pumped through the external cooling circuit with the cooler removing a maximum of approximately 5 hp in heat.

With this type of hydraulic mechanism, a loss in speed with load application is a function of volumetric efficiency of the hydraulic units themselves. Tests show a slip of 3 percent with 50 hp load when measured as a drop in output speed between no load and full load with a constant input speed. The governor senses this loss in speed automatically and makes up for this loss by readjusting the pump wobbler position to maintain constant speed.

Rates of response in the alternator drive-governor combination are extremely rapid. Full recovery from a speed disturbance in non-synchronous operation is accomplished in less than 0.1 second.

Once placed in synchronous operation, it is impossible to pull the alternators out of step under any normal conditions of engine acceleration or load application.

Synchronizing disturbances such as experienced during the closing of the synchronizing switch with speed differences existing between alternators in the order of one or two thousand rpm have been absorbed without detrimental effect on the drive. Random synchronizing is not only possible, but practical, on this type of equipment.

Operating experience to date indicates that with the refinements usually accompanying any large scale development such as this, the hydraulic drive described will meet all requirements intended in the design under all conditions met in aircraft application.

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COUPLING OR TORQUE CONVERTER?

(Continued from Page 12)

trial applications. Its advantages make it ideal for cranes and hoists,[2] logging and oil field equipment. In the latter field the installation of the converter on drilling rig drawworks has greatly reduced hoisting time. Also in the same field, the converter has been used on special purpose pump drives to provide the proper torque-speed adjustment to maintain maximum volume and pressure under every working condition, even when the output shaft is stalled. With a clutch type converter the pump can be disconnected from the engine during idling periods. The torque converted is also in wide use with independent rotary table drives, where it handles varying load conditions without gearing or any other fixed steps.

The torque converter has been adapted with considerable success to tractor drive.[3] The converter simplifies the transmission and minimizes gear shifting, provides more accurate control by increasing flexibility in any gear. Of great importance also is the fact that the "cushion" of power transmission extends the work-life of the tractor in the most severe service.

In transportation equipment the torque converter offers many advantages. In locomotives the automatic torque-speed selection assures smooth power under all driving conditions. Since the converter picks up the load there is no need for racing of engines or excessive clutch slippage. In motor cars, the converter is apparently on the threshold of a great expansion in the passenger car field. In addition to the Buick Dynaflow and the new Tucker converter drives, at least three other motor car manufacturers have torque converters in their laboratories and on field test. In the bus field the torque converter is already well established.[4]

In conclusion, we have distinguished between the two fluid drives — the hydraulic coupling, in which the output torque is always equal to the input and which is best suited for drives in which the prime mover is operating at uniform speeds and where output speed and torque requirements are fairly constant; and the hydraulic torque converter in which the torque is multiplied and which is best suited for drives where torque requirements vary and where increased torque is demanded at reduced output speeds.

[2] APPLIED HYDRAULICS, February, 1948, p 16.

[3] APPLIED HYDRAULICS, April, 1948, pp 24-25; May, p 3 and front cover.

[4] APPLIED HYDRAULICS, May, 1948, p 6.

SAVE THIS VALUABLE REFERENCE MATERIAL. BUILD UP A PERMANENT FILE

HYDRAULIC CIRCUITS, III

THE MANUAL OPERATION OF A DIFFERENTIAL CYLINDER WITH A PREFILL BY MEANS OF A CONSTANT DISPLACEMENT PUMP

By GEORGE N. DORR

Dorr-Patterson Engineering Company

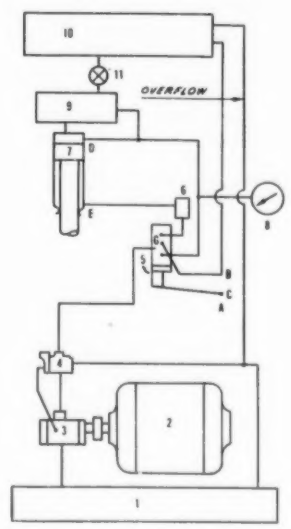
Detroit, Mich.

In this circuit a constant displacement pump is used to operate a cylinder by means of a manually operated four-way valve. The system utilizes a prefill tank from which fluid is drawn into the cylinder behind the piston. The flow of fluid from the prefill tank to the cylinder is through the prefill check valve (9). This valve is opened by vacuum and closed by spring and pressure when the rear-of-piston area is filled by fluid. On the return stroke fluid is returned to the prefill tank through valve (5).

CIRCUIT OPERATION

When the operating lever of four-way valve is moved to position "A", fluid enters port "D" of the cylinder, causing the piston to move downward. Fluid expelled through port "E" goes through flow control (check) valve (6). The downward piston movement creates a vacuum behind the piston; the pressure difference opens prefill check valve (9) and allows fluid from the prefill tank (10) to enter the area in rear of the piston. When this area is filled, the valve (9) closes and further downward movement of piston and ram is by direct pump pressure.

When the operating lever is moved to position "B", fluid is directed to cylinder port "E". This reverses the piston movement. When the lever is moved to position "C", the pump displacement is by-passed through valve (5) and the piston remains stationary if port "G" is blocked.



CIRCUIT DIAGRAM

1. Oil tank
2. Electric motor
3. Constant displacement pump
4. Pressure relief valve
5. Manually operated four-way valve, open center, port "G" closed
6. Flow control valve (check valve type)
7. Differential cylinder
8. Hydraulic gage
9. Prefill check valve, spring and pressure closed
10. Prefill tank
11. Stop valve

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TROUBLE SHOOTING CHART

When the system does not develop full pressure, it may be due to:

1. Prefill valve not seated
2. Not enough oil in prefill tank
3. Other reasons listed under this difficulty. See A5, June issue

When the system does not develop any pressure, the cause may be:

1. Prefill valve not closed or fails to open on downstroke of piston
2. Other reasons listed under this difficulty. See A5, June issue

When full speed does not develop, it may be due to:

1. Prefill valve too small or defective; does not open to fill cylinder on suction portion of stroke
2. Prefill tank capacity too small
3. Air vent in prefill tank too small
4. Stop valve (11) not fully open
5. Other reasons listed under this difficulty. See A5, June issue (except 4 and 5 which do not apply)

When down-stroke is irregular, up-stroke regular, check for:

1. Defective prefill valve or connecting line
2. Stop valve (11) which should be fully open
3. Other reasons listed under this difficulty. See A5, June issue (except 12 which does not apply)

When up-stroke is irregular, down-stroke regular, check for:

1. Sticking in the flow control valve (6)
2. Other reasons listed under this difficulty. See A5, June issue (except 4 which does not apply)

When both strokes are irregular, the cause may be:

1. Defective prefill valve
2. Other reasons listed under this difficulty. See A5, June issue (except 7 and 15 which do not apply)

When pressure builds to maximum slowly, the cause may be:

1. Prefill valve or its connecting line is too small or the valve closes too soon
2. Insufficient oil in the prefill tank or means have not been used to avoid cavitation of fluid when the piston is dropping
3. Prefill valve may not close tightly
4. Stop valve (11) may not be fully open
5. Other reasons listed under this difficulty. See A5, June issue

When full stroke is not developed, check for:

1. Reasons listed under this difficulty. See A5, June issue

When prefill tank overflows, the reason may be:

1. Tank is too small
2. Overflow line is too small or line is blocked or too high in the tank. This is a definite possibility if the press is run up and down without building up pressure.

Air in the system may be due to:

1. Not enough oil in the prefill tank
2. Cavitation of oil in prefill tank on filling stroke
3. Other reasons listed under this difficulty. See A5, June issue

If operation is noisy, look for:

1. Reasons listed under this difficulty. See A5, June issue

Heating up of oil may be due to:

1. Reasons listed under this difficulty. See A5, June issue

A motor running hot may be due to:

1. Reasons listed under this difficulty. See A5, June issue (except 2 and 3 which do not apply)

Applied HYDRAULICS DIGEST

Abstracts, summaries and listing of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions of special interest to the hydraulics field.

SAVE THIS VALUABLE REFERENCE MATERIAL! BUILD UP A PERMANENT FILE

Hydraulic Damping Device

New Drag Strut, *Aviation Maintenance & Operations,* May 1948, p 37.

A hydraulic damping safety device for reducing landing gear accidents, particularly dynamic overloading caused by resonant vibrations due to uneven runway surfaces and skidding on wet runways. The new strut permits a rearward motion of the main landing gear wheels up to six inches from the normal forward position. On the Constellation, Lockheed's standard passenger airliner, landings which approached the limit landing condition with a sinking speed of 600 fpm and a forward speed of 95 mph, the new hydraulic strut reduced the initial peak load by 32 per cent and the rebound to less than a fourth of its previous value.

Full Scale Working Model

L. R. Koepnick, *of Transcontinental & Western Air, Inc.,* from a paper delivered at the recent SAE national aeronautic and air transport meeting in New York City.

The design and pretesting of the entire hydraulic system now in use in Lockheed's Constellation is outlined. The proposed system was rather complex and there were some voluble critics who were sure that the hydraulic system would keep the plane on the ground most of the time. Since the system was being depended upon to operate the flight control surfaces in addition to performing the many functions normally handled by a hydraulic system, an unusual pre-installation setup and test was made.

The Lockheed company built an elaborate mockup of the hydraulic system—actually a full scale working model. The entire system was duplicated. From a cockpit mockup it was possible to "fly" the mockup in the research department, operating the flight control system by the hydraulic boost against loads equal to the aerodynamic loads later to be imposed on the surfaces. The nose wheel steered, the landing gear retracted, the flaps operated and the automatic pilot took over, all against loads exactly the same as those which later actual operation of the plane would impose. The "what ifs", conditions which Lockheed engineers specified for thorough checking, were run down through many hours of operation and design changes and modifications were developed and incorporated in the actual installation. The system in the Constellation caused much less trouble than, originally, had been expected, in fact far less trouble than much simpler hydraulic systems in other airplanes.

Air Gauge Controls Size of Cylinder Bore

Anonymous, *Compressed Air Magazine,* v 53, June 1948, p 143.

Two air circuits, one for control and one for gauging, incorporated in Hydrosize, a honing tool made by the Micromatic Hone Corporation, control the rate of expansion and the limit of cutting action in the tool. Compressed air at 6 psi passes through venturi fittings into each air circuit, which are independent of each other. A micrometer-adjusted metering valve regulates the pressure in the control circuit; two caliper bars, mounted on the hone head parallel with the abrasive sticks performs the same function in the gauging circuit. The pressure from both act on opposite sides of a diaphragm which operates an electric switch. Orifices in the two circuits are adjusted so that when the bore is smaller than the size desired, the pressure in the gauging circuit is greater than that in the control circuit. When the bore has been honed to the proper size, the gauge pressure drops below that in the control circuit, causing the diaphragm to move and close the switch. preventing further expansion of the honing head. The tool is then automatically collapsed and withdrawn.

Inverted Relief Valves

H. G. Conway, *Machine Design,* v 20, May 1948, pp 129-133.

By inverting the conventional relief valve—with a ball, poppet or disk, spring loaded against its seat by a compression or tension spring—it is possible to produce a valve that does not leak prematurely. In the conventional relief valve the seat pressure is proportional to the difference between fluid pressure and spring load. The force between the valve and seat is reduced as the pressure increases; the valve is sensitive and as the pressure approaches the opening point it will tend to seep.

In the inverted relief valve type the valve seat is spring loaded against valve member or ball

(Continued on Page 29)

By EINAR ALMDALE

HARNESSING FLUID POWER

The lack of consideration given fittings, particularly on high pressure systems, often allows improper or hastily chosen fittings to become the weak link in hydraulic circuits. A veteran advocate of hydraulics believes that fittings should be selected just as carefully as is any other part of such a system.

EINAR ALMDALE

Einar Almdale, plant manager of the Midland plant in Cleveland, is directly in charge of the purchasing, engineering and manufacturing activities of his company. Of inventive turn of mind, Mr. Almdale has had over 40 patents issued in the field of automotive frames.

IN THE PURCHASE of hydraulic equipment we have found, and frequently the hard way, that no element of a fluid power system can be neglected. Tube fittings, for example, are sometimes given scant attention or none at all until a system is ready to tube up. We have been just as guilty of this practice as have many others. A relatively recent experience with automatically controlled hydraulic piercing machines, which we use to punch rivet holes in the side members of automobile frames, made us realize that fittings had to be selected with the same care as any other part of a hydraulic circuit.

Early in 1946 we purchased four of the hydraulic piercing machines. Each of these machines (Figures 1 and 2) consists of a number of individual piercing units or "hydraulic guns", with the dies of each unit arranged at accurately spaced intervals to receive an irregularly shaped side member of a frame for the piercing operation. The side member is accurately located in the dies by locating pins and gauges, to insure that all rivet holes are in their exact and proper relationship. The cylinders of the hydraulic guns are not all the same size, since some punch a single hole, while others punch a cluster of holes.

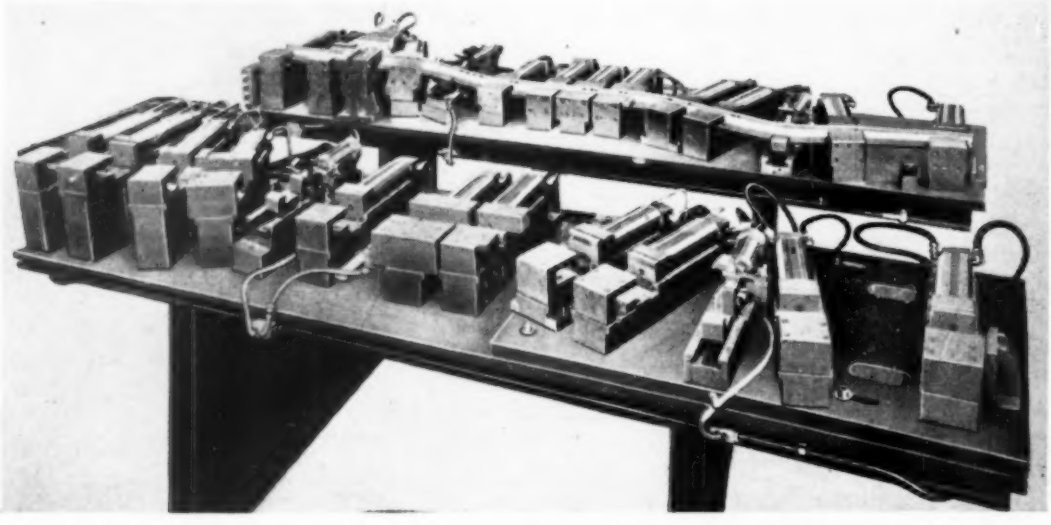

Fig. 1. Two of the automatically controlled hydraulic piercing machines. The variation in size of hydraulic guns and the flexibility of arrangement makes it practical to pierce holes in a wide range of sizes and shapes in side members.

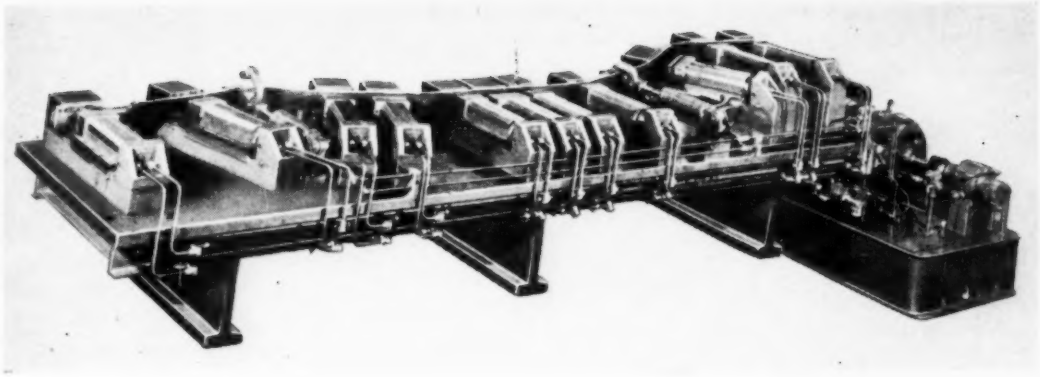

Fig. 2. The rear of one of the eleven gun machine assemblies, showing motor, pump, tank and master control valve. The two locating gauges are also shown, the one at the left open.

A total of eleven piercing units or guns make up the machine assembly. On the power stroke the cylinders are operated at 5000 psi and on the return stroke at 1000 psi. All the cylinders are controlled by one master control valve. While the cylinders operate practically together for the piercing operation, several cylinders operate with a slight delay in order to reduce the transient fluid shocks incident with the sudden application of 5000 psi pressure for the power stroke.

The use of the hydraulic guns eliminated the need for the expensive cam operated dies formerly used, since the return stroke performs the stripping automatically. By the use of these machines we were able to increase the production of the piercing operation for automobile frames by 20 percent.

In our endeavor to get our new piercing machines into early production, and being confronted with the problem of designing and constructing new piercing dies, no particular attention was paid to the type of fittings selected. We used ordinary flare type fittings throughout the tubing system.

After these machines were in production a few weeks we began to encounter failures in tubing and in tube fittings. We attributed these failures to excessive fluid shocks and to the vibration inherent to the sudden application of the 5000 psi pressure on the power stroke.

New tubing was installed and the original fittings were replaced by a three piece flare type fitting. Since that time we have had no fitting failures. Our engineering department came to the conclusion that the use of a hardened sleeve used in these fittings was the answer to our problem of tube breakage.

In my thirty five years' service with my company I have been an active proponent of hydraulic instead of electronic controls. Based on my experience I find that hydraulics is more flexible of application for reciprocal movements as required for piercing and for driving cold-head rivets for assembling the various parts of automobile frames. We advocated the use of hydraulic guns long before they were actually on the market as a production item of manufacture. In fact, it was through our encouragement that a present leading manufacturer of these guns owes its early existence.

Naturally, many of these early hydraulic guns and piercing dies were rather crude. However, through our constant endeavor to improve our production with increased efficiency, we have made many improvements in our piercing units. The units shown in Figures 1 and 2 are our present design.

I have witnessed the growth of the hydraulic industry from a few small concerns to a nationwide industry. In the early days many of the systems were operated by hand controlled valves for effecting the required sequential movements. At the present time many complicated operations of a sequential nature are performed in a complete duty cycle by automatic controls using cams, dogs, toggles, pilot plungers and many other quick acting members.

My experience has been that the principal obstacle to a more universal acceptance of hydraulics is the problem of fluid leakage; this is one reason why I am glad to bring my experience to the attention of other users of hydraulic equipment.

Tube fittings may be considered as individual links in the fluid circuit and fluid power developed is no greater than the strength of the weakest fluid connection. Fittings which connect tubing to valves or cylinders should be selected with the greatest care. This is particularly true where the system is subject to high fluid pressures and extensive vibrations due to fluid shock, which is the No. 1 killer of hydraulic tubing. Hydraulic leakage not only drains fluid power from the system, but invariably acts as a detriment in curtailing a wider acceptance of hydraulic systems.

In studying the problem of fluid leakage, one readily and naturally becomes an advocate of new and well-engineered products which serve to aid hydraulics. Our experience is that the tool steel sleeve fittings will

do much to stop fluid leakage.

The harnessing of fluid power in a high pressure system is a difficult problem in applied hydraulics. The fluid is slippery, slick and powerful under pressure—able to suddenly burst from the fluid circuit or to silently ooze or seep away. Fluid power under heavy operating pressures plus the transient fluid shocks caused by the sudden opening and closing of a valve plays particular havoc with ordinary fitting assemblies. This has caused many an engineer to "play safe" by designing down to lower pressure systems and the inefficiencies of bulky cylinders and large piston areas.

To obtain trouble-free sealing of fluid power to meet all conditions is a difficult achievement. Undoubtedly, there are other types of fittings, both standard and special, that, when selected with the same attention given other parts of a hydraulic circuit, will give satisfactory results. The basic principle of "attention to all details", when followed, will extend the applications of hydraulics and increase the successful applications.

International Road Show

The 45th Annual Convention and International Road Show, sponsored by the American Road Builders Association, will be held at Soldier Field, Chicago, July 16 to July 24.

Over 300 manufacturers will exhibit the latest in highway and airport construction machinery. The exhibits will cover over 30 acres and will total over 5000 pieces of equipment. A very wide range of hydraulic structures, elements and controls will be shown both as integral parts of equipment and separately by hydraulic manufacturers. Contractors, manufacturers' representatives, highway officials and other buyers and road building authorities from all over the world are expected to attend.

A national highway and airport construction program for 1948 totalling $1,500,000,000 makes this show both timely and important. It is estimated that state, county and municipal governments will require $240,000,000 for maintenance equipment and $265,000,000 for new construction equipment. This is the greatest expenditure in construction history.

A number of important papers by leading authorities will be presented at the convention technical sessions. There will be papers of special interest to contractors, road and bridge builders, engineers and buyers in the construction and maintenance fields. Other papers of special interest to manufacturers of road machinery and accessories are scheduled. Among topics to be discussed are highway engineering, airport construction, highway safety and highway maintenance.

This is the first road show held since 1940 and it will be the largest ever held.

HYDRAULIC EQUIPMENT FOR HONING MACHINES

(Continued from Page 21)

and a rack and pinion. The working stroke is obtained by settings of dogs on the control dial. The hones are withdrawn from the bores by intercepting the operation of the rack with a solenoid latch.

Reciprocation is started by energizing solenoid four-way valve (3), which causes special check valve (2) to close. When this valve is degenerized, the oil flows through valve (2) to tank at practically no pressure.

The second, smaller pump of the tandem furnishes oil for several purposes. First, it is used for fixture operation. By the setting of by-pass valve (8), a clamping pressure of at least 100 psi is maintained on the fixture cylinder. Operation is controlled through four-way valve (9). The oil that breaks over by-pass valve (8) is used to charge the accumulator circuit. Relief valve (12) determines the pressure of this circuit. Oil is taken from the accumulator to operate the spindle engagement clutch cylinder through solenoid four-way valve (11). Finally, oil is taken to expand and collapse the hones through solenoid four-way valve (16).

In the hone expansion cylinder assembly shown, the cylinder to the right is used for expanding the hone. The cylinder to the left is the control cylinder which feeds a cam allowing expansion to take place at a predetermined rate. This construction allows rapid expansion of the hone to the bore size as well as the metering of a larger volume of oil in a given time, gaining more accurate control.

In order to maintain an accurate time of hone expansion, a motor driven metering pump (19) is used for metering the oil from the control cylinder. This pump runs at a constant speed and has an adjustable displacement. The pump is designed so that it can meter the oil accurately, drop by drop if necessary. A solenoid four-way valve (21) is used to by-pass the metering pump to expand the honing tools rapidly to the bore size, e.g., when reentering a block that is slightly undersize after honing.

The bladder type accumulator is charged with air at approximately 100 psi. The accumulator stores up oil during the honing cycle and between cycles so that oil will be available to rapidly engage and disengage the clutch and collapse the hones. This makes it possible to get the effect of a much larger pump. Figure 3 shows the panel mounting of the hydraulic valves on the side of the reservoir. The pump itself is on the inside of the reservoir and is accessible from the top.

The flexibility, smooth acceleration and rapid reversal of the honing head have made honing machines an ideal application for hydraulic equipment.

DIGEST

(Continued from Page 25)

and seat pressure is directly proportional to the fluid pressure up to the point at which the rod contacts the valve member and opens it.

In the inverted relief valve the valve seat moves as a piston and carries with it the valve member or ball. The ball is pressed against the seat with increasing force as the pressure rises. This compresses the spring, forces the seat and ball down until an axial rod is contacted. After contact the pressure acts on the area between the piston and the seat and increases until the valve seat moves away from the ball. During this stage the inverted valve acts as a normal relief valve.

As the valve seat moves away from the ball a damping effect is obtained because of the piston type seal used. Excessive friction, though, would cause a lag in the closing of the valve as the pressure dropped; a modified version would have to be used on certain machine tools because of the relatively short seal life.

Several different types of inverted relief valves used in England and Frances are shown in cross-sectional drawings; a short history of the development of this valve is also included.

The principal advantage of the inverted relief valve is that its piston action acts as a damper and by merely providing it with adequate displacement capacity it will not prematurely leak even when subjected to severe hydraulic shocks.

Why Pneumatics?

Harvey F. Gerwig and Joseph F. Famme, *Machine Design*, v 20, June 1948, pp 116-121.

The authors, assistant group engineer and project engineer, respectively, of Consolidated-Vultee Aircraft Corporation, San Diego, analyze and champion the high pressure pneumatic system on the new XB-46 high speed bombers. The pneumatic system operates landing gear, bomb-bay doors and brakes from accumulators, ground charged at 1500 psi. The authors maintain this system was the best engineering answer to their problem. They list eight primary advantages as: (1) less weight for the horsepower delivered; (2) least power drawn from the engine in flight (due to ground precharging); (3) the media, air, is always available at no initial cost; (4) there is no fire hazard; (5) it is the cleanest of all possible systems; (6) there is practically no ambient temperature problem because air has a very low viscosity, does not congeal, operates at an insignificant line friction and being compressive, does not exhibit serious shock waves; (7) the compressibility of air makes cushioning or

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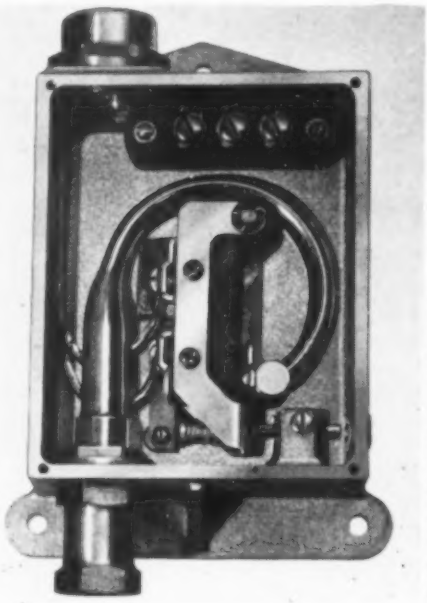

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snubbing practical and easy without impact; and (8) sonic velocities can be achieved when the air storage pressure is twice that of the operating pressure.

The pneumatic system includes the following major pieces of equipment: (a) accumulators or storage bottles which store air pressure at 1500 psi, providing sufficient potential energy for two cycles of operation without recharging; (b) low-capacity, engine-driven two-stage piston type compressors; (c) adjustable pressure regulators using optically flat lapped-plate poppet; (d) diaphragm-spring type of relief valves; and (e) shear-flow selector valves. Both check valves and fuses are similar to those used in a hydraulic system; the check valve with a metal seat and a plate poppet and an adjustable fuse operating on a quantity-measuring principle. Tests indicated that the most economical installation of the brake valve was on the main landing gear with foot operation by means of a remote control, self-contained hydraulic master and slave system. The landing gear can be used as an accumulator, so that air delivery lines to the brakes are very short. Split-second operation is accomplished by venting exhaust air at the valve. To eliminate the need for hydraulic remote control of the brake valve, a revision of present-day low-pressure air brake systems could be employed. Another means of accomplishing this would be with pilot-operated control valves.

This the first half of a two part article.

Pneumatic Muscles Clamp and Assemble

Chester S. Ricker, *American Machinist*, v 92, June 17, 1947, pp 112-113.

"Its news when the doctor takes his own medicine." The Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, has been making automotive air-brake operating devices for years but it took some of the company's own production men to open the eyes of management to the possibilities of these units for their own shop work. At present over 500 jobs are being done in their plant with their own "Robotair" and "Rotochamber" units. The "Robotair" is an air chamber with a flat diaphragm that is connected through a control valve to the plant air line. The unit is quick-acting, requires little operator effort and is readily installed on new and old machines alike. The newer "Rotochamber" has a tubular diaphragm and thus a smaller diameter for an equivalent effective diaphragm area. Principal applications are as clamping fixtures, single and in multiple, bench arbor presses, vises and inspection fixtures. Most units are attached directly to the reaction or anchor plate which may be arranged in the most convenient way for mounting and operating when the fixture is designed. The air force is transmitted by levers, slides, wedges or toggles. Action is controlled by a lever-operated air valve in the line A choice of five valves may be made.

New PRODUCTS

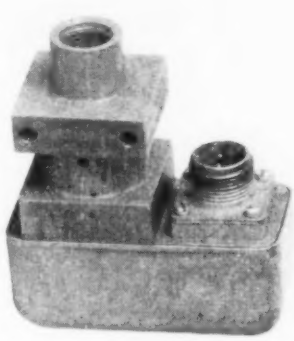
For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Hydraulic Power Unit

B. F. Perkins & Son, Inc., now offer to industry the hydraulic power units previously manufactured for their own applications. The units consist of electric motor, hydraulic pump, relief and bypass valves and oil reservoir and combination filter and oil level gauge. The complete unit is enclosed in an outer housing and mounted on a solid base. Three types are offered: high pressure units, delivering to 7500 psi; low pressure units, delivering to 1200 psi; and dual pressure units, delivering 1000 psi continuous pressure. Use Business Reply Card, mark NP-1.

Pressure Switch

A new line of pressure switches is now being manufactured by Saval Co. Designed to make or break an electrical switch according to pre-set pressures, this switch can be made to operate through the range from 100 to 5000 psi. It compensates for temperature changes; maintains constant



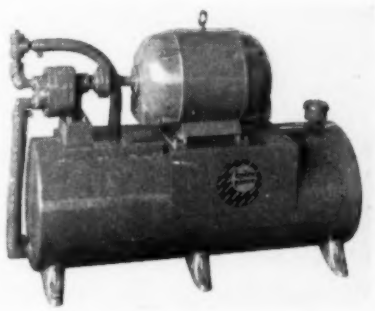
setting from minus 50 to 150 F. Automatic operation of sequencing valves and automatic control of pumps and hydraulically controlled systems are some of the applications for this switch. Use Business Reply Card, mark NP-2.

New Hydraulic Hose

A new hydraulic hose capable of withstanding working pressures to 3000 psi is now being manufactured by The B. F. Goodrich Company. Special steel wire with a tensile strength of 400,000 psi is used in the construction of this hose. Used on some of the largest new airplanes, this hose has been found to withstand pressures far in excess of the 3000 psi required. Use Business Reply Card, mark NP-3.

Low Cost Power Unit

A new series of packaged hydraulic power units is now available from Hydro-Power Di-



vision, The Hydraulic Press Mfg. Company. Designated the "Cubline", these small power units require very little mounting space. Three capacities 6, 10 and 15 gpm, are offered. Each power unit consists of 1000 psi gear pump, 35 gal oil reservoir, relief valve, coupling and pipe fittings. Use Business Reply Card, mark NP-4.

Flaring Tool

The Imperial Brass Mfg. Co. announce a new fast operating flaring tool for producing flares without tube scoring in soft copper, brass and aluminum tubing. It will handle the most popular tube sizes ranging from ¼ to ⅝ in. In place of the usual bar, a new die holder with sliding die blocks is used for gripping the tube end; die blocks are of extra depth and smooth surface. Use Business Reply Card, mark NP-5.

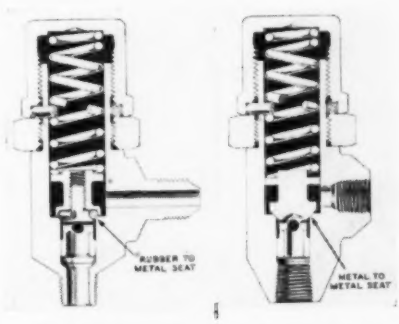
Hydraulic Relief Valve

Fluid Controls, Inc. have available a pressure relief valve adjustable over a range of 4,000 psi. It is a pilot type valve of spring loaded, poppet design. Capacities range from 2½ to 10 gpm at from 200 to 4000 psi. The valve is compact and light

weight and generally requires no mounting bracket. Use Business Reply Card, mark NP-6.

Relief Valves

The Parker Appliance Company has introduced a new line of hydraulic and pneumatic relief valves. The valves, available in five pressure ranges from 0 to 450 psi, can be set to any desired pressure by external adjustment. In the hydraulic model the piston makes a metal-to-metal seat; for pneumatic service an "O"-ring rubber-to-metal seat is used. The full series of pressure ranges are available in six basic sizes from ¼ to



¾ in; larger sizes and pressures available on request. Use Business Reply Card, mark NP-7.

Automatic Water Ejector

National Pneumatic Company is manufacturing an auto-

matic water ejector for draining compressed air systems. The ejector does not connect the compressed air system to the atmosphere; therefore, there are no pressure losses. With the ejector, pipe and fittings are furnished to provide a vertical sump. At 100 psi, 30 cycles will discharge 1 qt of water. The automatic water ejector eliminates manual draining of air lines and prevents water damage to equipment and personnel. Use Business Reply Card, mark NP-8.

Solenoid Air Valve

An improved 4-way solenoid operated air valve for control of double acting cylinders is announced by Mechanical Air Controls, Inc. The design incorporates ease of operation of the balanced type valve and poppet

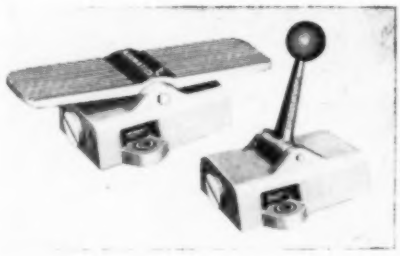
type valve construction. The ⅜ in. size only is now available and larger sizes will follow. Operating pressures range from 0 to 150 psi. Use Business Reply Card, mark NP-9.

New Hydraulic Pump Design

Cannon & Company is now producing a newly developed hydraulic pump incorporating the Dudley "Nutating Plate" piston type unit with rotary valve. Simplicity of design eliminates many of the parts used in conventional pumps — the drive shaft is the only revolving unit. All necessity for packing against internal pressures are eliminated and the rotary valve, an entirely new feature, is full floating and hydraulically balanced. Use Business Reply Card, mark NP-10.

Hand and Foot Air Valves

Low-cost, hand and foot controlled air valves for 3 and 4-way operation have recently been developed by Airmatic Valve, Inc. Both types have the same internal parts and are designed for locking and non-



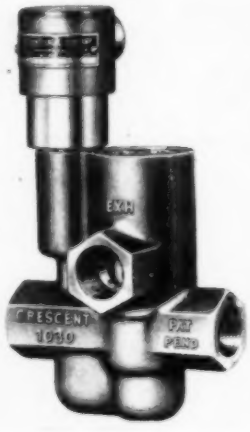
locking with neutral. Either hand or foot controlled type is available in ¼ in pipe size. Use Business Reply Card, mark NP-11.

High Speed Press

Denison Engineering Company offers a 4-ton capacity hydraulic press that is three times faster than the standard Multipress models previously offered. Design changes in the control system, operating component and power system produce the new high speeds. Use Business Reply Card, mark NP-12.

New Three-Way Air Valve

A new fast-acting, pilot-actuated, solenoid controlled 3-way valve is announced by Crescent Valve Company. It can be used with air, water and light oil. Available for either "normally open" or "normally closed" operation, these valves were designed for pressures from 25 to 140 psi. Available sizes



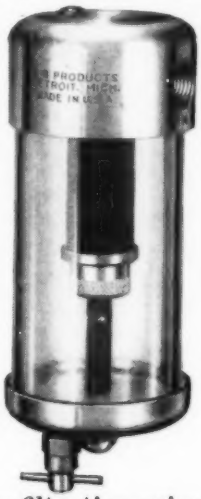
range from ¼ to 1¼ in, with screw-in type solenoids. Use Business Reply Card, mark NP-13.

Electronic Counter

Multiple sequence electronic counters, that predetermine selected counts occurring in sequence, are manufactured by Potter Instrument Company. It will predetermine three different counts occurring in sequence ranging from 1 to 10,000. The output circuit consists of three high speed mercury relays. Use Business Reply Card, mark NP-14.

Air Line Filter

For removing water, dirt or oil from air lines, M-B Products offers a ribbon type filter. A transparent bowl of plastic shows the amount of foreign matter accumulated removing all guess work for service attention. This unit functions on



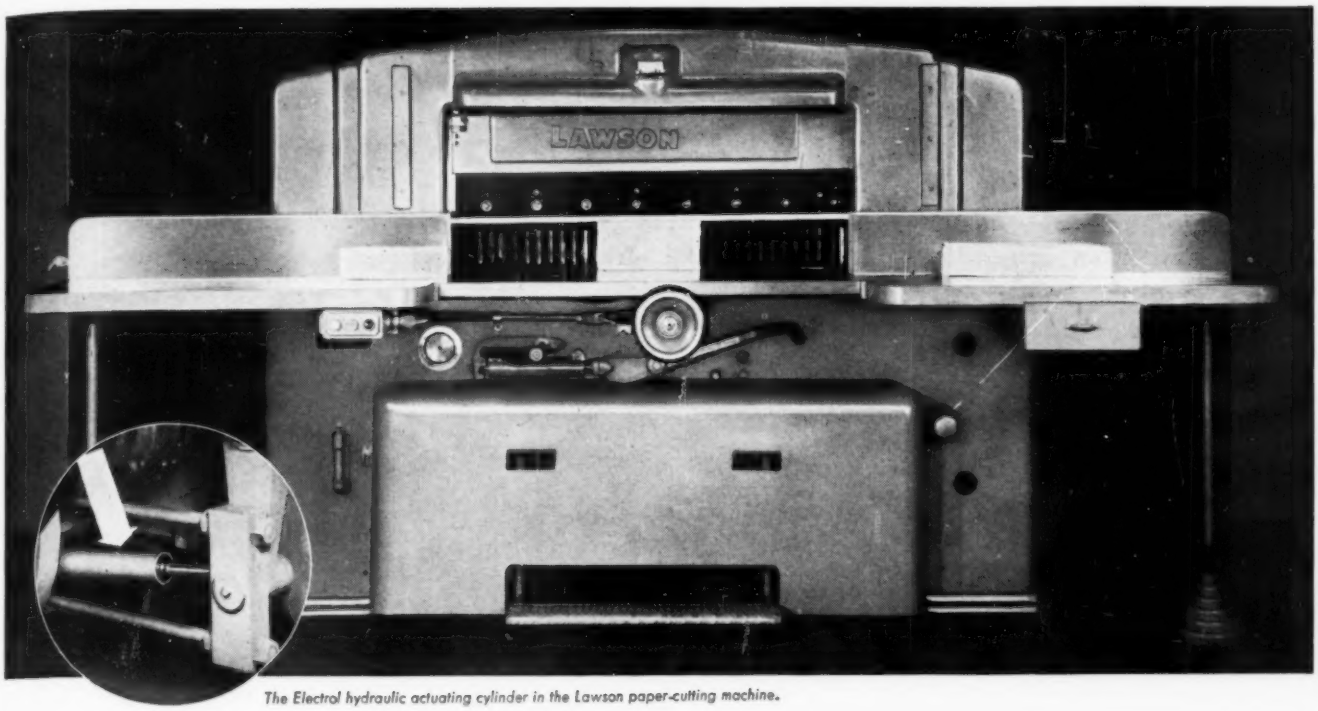
the edge filtration principle and removes particles as small as 10 microns. Available in five sizes ranging from ¼ to 1 in pipe. Use Business Reply Card, mark, NP-15.

Time Delay Relay

Ward Leonard Electric Co. has developed a motor driven time delay relay with composite connections. This ac relay is designed for use in processing, machine tool, and other control equipment where an adjustable time delay, after closing the pilot circuit, is required. Two timing sequences are obtainable, "delayed make and instantaneous make" or "delayed break." Timing is easily adjustable over a wide range up to 63 minutes. Use Business Reply Card, mark NP-16.

TIP-TOE TREADLE ACTION CONTROLS TONS

with Hydraulic Engineering by Electrol



The Electrol hydraulic actuating cylinder in the Lawson paper-cutting machine.

How E. P. Lawson Company Built the First Successful Automatic Hydraulic Clamp Paper Cutter

Attracting wide attention is the new paper-cutting machine developed by E. P. Lawson Company's Frederick W. Seybold, world-recognized authority on paper cutter design and engineering.

One outstanding improvement in the Lawson machine is the use of an automatic hydraulic clamp and tip-toe treadle, which not only assures greater accuracy in cutting, but is far easier on the operator. It has other advantages, too, such as greater flexibility, faster operation and less maintenance.

To perfect this device Electrol engineers were called upon to design and build the hydraulic actuating cylinder, and supply the standard check valves of the system, without which these advantages would not be possible.

This is but one of many examples of how *hydraulic engineering by Electrol* is aiding designers to improve equipment in many fields of industry. It suggests, too, that the skill and experience of Electrol may prove of help to you in obtaining better machines for your own use—or for embodying hydraulic devices in the products you make.

Electrol engineers invite your inquiries . . . offer their co-operation in solving any problem involving hydraulics.

Electrol

INCORPORATED

KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

FOR BETTER HYDRAULIC DEVICES

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

Lindberg Engineering Co., Chicago, has acquired the assets of the Electronics Division of the Illinois Tool Works. John A. Callahan will continue as manager of the division for Lindberg. The new division will occupy space in a new building recently erected adjacent to the present Lindberg plant.

Lear, Inc., Grand Rapids, Mich., announces the acquisition of Romec Pump Co., Elyria, Ohio.

Manning, Maxwell & Moore, Inc., announce the acquisition of the Hydraulics Division of the Airex Manufacturing Company, Long Island City. Norman Collins, hydraulic engineer for Airex Manufacturing Company, and other key personnel will continue operations at the Jersey City plant of Manning, Maxwell & Moore.

Leading British manufacturers of hydraulic equipment have formed the British Hydromechanics Research Association to gather data on problems confronting members and to coordinate research activities. A program of cooperative research is planned which includes the use of university and technical school laboratories. The association will work closely with the newly established Mechanical Engineering Research Organization, a government project under the Department of Scientific and Industrial Research. Studies will be largely confined to enclosed fluid flow and will include pumps, valves, turbines, presses and other hydraulic equipment.

The Hydro-Power division of The Hydraulic Press Mfg. Co. is in the process of moving from Springfield, Ohio, to the main plant at Mt. Gilead, Ohio.

Haskel Engineering & Supply Company, Glendale, California, has been appointed distributor for The Parker Appliance Company, Cleveland, Ohio. This appointment will supplement the activities of Metropolitan Supply Company, Parker distributor in Los Angeles.

Link-Belt Co., Chicago, announces establishment of two new district sales offices. One is in Charlotte, N. C. with Thomas H. Appleton appointed district sales manager. The other is in Wilmington, Del. with William H. Kinhead as district sales manager.

The Heil Co. of Milwaukee has made the following appointments: Harry F. Pugh, formerly assistant to the president, vice president in charge of sales and advertising; Arnold F. Meyer, formerly chief engineer, vice president in charge of engineering; Joseph J. Roseecky, formerly works manager, vice president in charge of manufacturing; J. F. Horn, formerly controller, assistant secretary and treasurer; Allen E. Magee, formerly company attorney, assistant secretary; William E. Simmons, formerly a divisional manager, general sales manager; E. G. Gilmore has been made assistant treasurer and Edward Fellows Jr., has been appointed director of purchases.

National Association of Relay Manufacturers have reelected Ralph T. Brengle, Potter and Brumfield Sales Co., as president. At the same time five new members were appointed to the standards and nomenclature committee for 1948. They are: J. E. Mossman, Phillips Control Corp., chairman; E. H. Gillette, Allied Control Corp. Inc.; F. W. Falck Jr., Advance Electric & Relay Co.; R. M. Brumfield, Potter and Brumfield Mfg. Co. Inc.; and F. F. Rowell Sr., Guardian Electric Mfg. Co.

E. B. Wiggins Oil Tool Company, Inc., Los Angeles, has inaugurated a new Special Equipment Division to assist manufacturers in the development of quick disconnect couplings as standard equipment on their products. James A. Roberts has been appointed head of this division, with headquarters in Los Angeles.

The Armour Research Foundation of Illinois Institute of Technology has prepared a brochure on the facilities offered to industry by their Metals Research Laboratories. Seven industrial-scale pilot plants and a staff of experienced metallurgists and metallurgical engineers are available for research on a confidential basis. Facilities available cover work ranging from foundry processes to welding.

Seamless Steel Tube Institute has moved its offices to 1901 Oliver Building, Pittsburgh. C. G. Macdonald is secretary.

The Committee on Engineering Education of the Compressed Air and Gas Institute has prepared a thirty-minute illustrated lecture on compressed air and its industrial applications. The lecture, entitled "Compressed Air in Action" may be presented by either a 35-millimeter film strip or by 2x2 in film slides. It is available at cost to industrial organizations, technical societies, schools, foremen's clubs and other interested groups.

Allen-Bradley Co., Milwaukee, manufacturer of control equipment, has moved its Chicago office to new and larger quarters at 445-7 N. LaSalle St.

REPRESENTATIVES WANTED

Industrial Sales and Engineering Service Representation, in territories not yet assigned east of the Mississippi, being sought by a well-known manufacturer of fluid and pneumatic controls. Inquiries from established engineering-sales organizations should be directed to Classified Dept., APPLIED HYDRAULICS.

BOOK REVIEWS

Electronic Engineering Principles

John D. Ryder. *Professor of Electrical Engineering, Iowa State College. First Edition. 389 pages, 6 x 9 inches. Published by Prentice-Hall, Inc.*

The material in this book was chosen as the physical fundamentals considered essential for the understanding of electron tubes. While prepared as a text, theory and application are closely grouped and applications are chosen largely from the industrial field. While a rather substantial mathematical, electric circuit and physical background is assumed by the author, many men with practical backgrounds or with uneven academic training should be able to extract a great deal of useful information from this book. After an excellent introductory chapter which is called "electron ballistics", separate chapters are devoted to diode rectifiers, vacuum triode, triode amplifier, emission, secondary emission, gaseous conduction (including the quantum theory) and photoelectric cells. There are over 250 figures, the majority of which are circuit diagrams and characteristic charts.

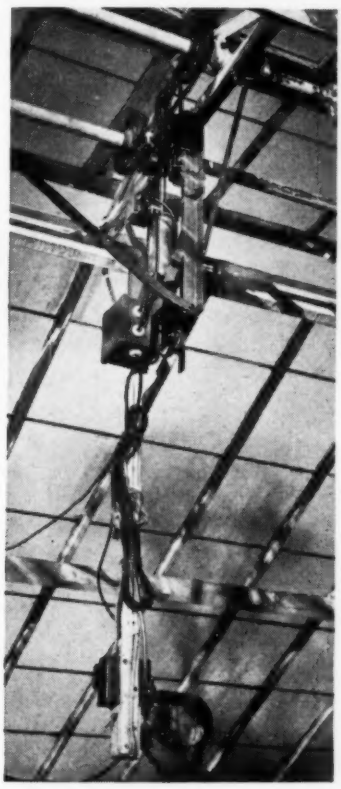
Relay Engineering

Charles A. Packard. *Chief Engineer, Struthers-Dunn, Inc. Second Edition. 628 pages, 4 x 6½ inches. Published by Struthers-Dunn, Inc. at $3.00.*

The sub-title, "a reference book to guide engineers and others in the selection and use of electromagnetic relays" is an accurate statement both in purpose and content. Eleven chapters survey the relay field and give a comprehensive and well organized fund of directly useful information on practically every type and application of relays in industry. Since the work is that of a specialist of many years experience, many electrical, magnetic and mechanical problems that recur in relay applications are treated clearly and authori-

(Continued on Page 38)

AIR CONTROLLED GARDENING



IN COMMERCIAL greenhouses it is highly important that uniform temperatures be maintained at all times; a sudden change in temperature can cause the complete loss of a valuable crop of flowers or vegetables.

In order to maintain a constant temperature, many greenhouse operators have found it necessary to hire a number of men to work on a twenty-four hour, seven-day week basis. It was necessary for these men to continuously raise and lower the windows with any rise or fall in room temperature.

To eliminate this necessity for relying on human control, the Massachusetts State Experimental Station at Waltham, Massachusetts under the direction of Professor R. M. Koon, developed a unit that incorporates an air motor actuated by solenoid valve and controlled by a thermostat. The thermostatic control, set at a maximum and minimum temperature, will raise the window to any desired height when the temperature becomes too high and lower it when the temperature drops below the minimum setting.

The windows can be raised to any position, from fully closed to ninety degrees open; the degree of opening is controlled by a manually operated master switch. The master switch actuates a dog that makes contact and over-rides a normally open switch. This energizes a solenoid coil in the valve attached to the air motor and cuts off the flow of air to the motor. With the air supply interrupted, the forward travel of the piston is stopped and the position held; the piston will hold this position until the temperature falls to the lower level previously set on the thermostat.

When this temperature is reached, the other coil is energized and the solenoid valve opens. The piston now starts to retract, reopening the normally open switch and returning the piston to its original position — with the windows completely closed.

Although this setup is experimental, the possibilities for applications to large commercial greenhouses and to industrial plants and buildings are quite apparent. This type of application assures fool-proof operation and accurate temperature control — factors necessary in successful operation of commercial greenhouses.

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

1. Hydraulic Pumps and Valves ... The variable volume hydraulic pumps and the balanced piston, sleeve type valves produced by Racine Tool and Machine Co. are reviewed in Catalog No. P-10-C. The pumps are of the radial vane type and are offered in three standard models —12, 20 and 30 gpm—rated for continuous operation up to 1000 psi. The standard hydraulic controls offered include manual, solenoid, pilot and mechanically operated valves in sizes ranging from ¼ to 1½ in pipe size. Special valves and hydraulic pressure boosters are also shown. Schematic drawings showing typical applications for pumps and photographs showing the equipment styles and shop applications are included.

2. Air Cylinders . . . Folder A-10, prepared by A. Schrader's Son Division of Scovill Manufacturing Company, Incorporated, describes their single and double acting air cylinders. Air valves are also described. Four diameter sizes ranging from 1½ to 4 in are offered with stroke lengths from 1 to 18 in. A variety of mountings with or without cushions are available. Air strainers, speed control valves and 3 and 4-way valves are also shown. Drawings and specification charts detail each type of cylinder.

3. "O"-Ring Handbook . . . Plastic and Rubber Products, Inc. has prepared a Handbook of "O" Ring Hydraulic Packings as an aid to hydraulic and pneumatic engineers. Principles of operation, suggestions on methods of adaptation and hints on outlining data necessary in solving hydraulic packing problems are included in this 32-page booklet. Cross-sectional drawings show in detail the various applications of "O" rings to valves, cylinders and tube fittings. Also included are charts of size and dimensional data for commonly used "O" rings and leather washers. The section at the end of this handbook is devoted to the production facilities and the products of this company.

4. Hydraulic Remote Control ... Bulletin EHC-78E describes the hydraulic remote control unit produced by Sperry Products, Inc. This unit, consisting of a transmitter and a receiver connected by a single tube, can be used for remote control of industrial, marine and aircraft equipment. Fluid pressure in system approximates 200 psi. Pressure stroke produces 350 in-lb torque; return stroke delivers 100 in-lb torque. Schematic and detail drawings showing design features and photographs presenting typical applications of this unit are included.

5. Hydraulic Valves . . . R. D. Wood Co. has available a loose-leaf, data sheet catalog on their hydraulic valves. High pressure valves of the straightway stop type, operating release type and straight way check type, for service to 6000 psi are reviewed. Also described are high pressure hydraulic operating valves of the stop and release type, three and four-way piston type and three and four-way balanced spindle type of the same operating capacities. Other miscellaneous valves, gauges and packings are shown.

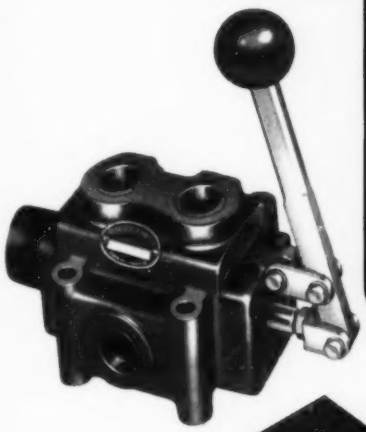
6. Hydraulic Equipment . . . The hydraulic pumps, valves, cylinders and hand operated units produced by The Commercial Shearing & Stamping Company are described in their general catalog. Pumps are of the gear type and suitable for intermittent pressures to 1000 psi; power take-off and combination units are offered. Valves are of the balanced spool type for flow control and can be obtained in any multiple arrangement required. Cylinders are single acting, double acting and telescopic; the very complete telescopic units are furnished in hoist assemblies. Photographs, drawings and suggestions for installation and maintenance of hydraulic circuits are included.

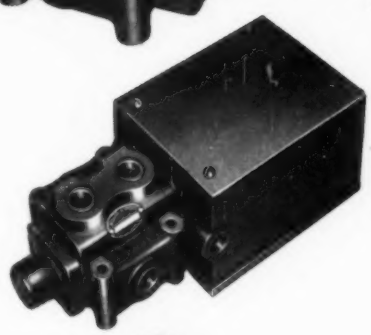
7. Air and Hydraulic Cylinders ... Bulletin 448, Power Plus Products Company, reviews the air or low pressure oil cylinders produced by this company. Air or hydraulic cylinders, Series 3500 for pressures up to 200 psi; and hydraulic cylinders, series 4500 for pressures up to 750 psi are described. Both series are offered in bore sizes ranging from 1½ to 14 in diameter. A variety of mountings and connector setups are available.

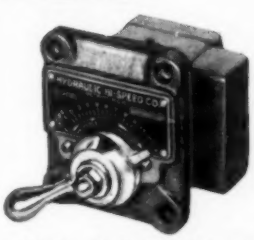
8. Piercing Units . . . A complete line of hydraulic piercing units is presented in Mueller Engineering Co. general catalog. Hold-down and stripping operations are hydraulically powered. A section on engineering data includes square bodied cylinders with capacities of 40 to 227 tons at 10,000 psi and rectangular body cylinders with capacities up to 16 tons at 5000 psi, in horizontal or vertical mountings.

9. Rotary Gear Pumps ... John S. Barnes Corporation describes their Constant-flo rotary gear pump in Bulletin 101-GP. The pump illustrated has a capacity ranging from 1 gpm at 600 rpm to 4 gpm at 2400 rpm. Other standard pumps are available in larger capacities. Pressure range, in excess of 400 psi, is adjustable to any operating condition by a built-in relief valve. This valve is optional. In addition to drawings, photographs and an efficiency chart, several specification sheets on different pump models are included.

Double-A Hydraulic Manufactures Oil Control Valves for all applications.







Double-A Hydraulic Offers

a complete Hydraulic Oil Control Engineering Service

If your problem is to push . . pull . . . lift . . . lower . . . press . . . rotate . . . feed — then Double-A Hydraulic engineers can help you. Hydraulic oil power can give you precision control . . . smooth, quiet, powerful operation . . . compact installations . . . and remote control if wanted.

Our technical experts have years of experience in this modern way of doing mechanical jobs. Their experience is available for the asking—just drop us a line or 'phone in Manchester at 4511. We'll be glad to serve you.

Double-A Hydraulic Hi-Speed Co. manufactures a complete line of top quality oil control valves. We carry many standard items in stock for immediate delivery and we can make good delivery on special valves. Every valve of our manufacture is fully guaranteed for its rated function. Get in touch with us or one of our distributors today.

HYDRAULIC HI-SPEED DIVISION OF DOUBLE-A PRODUCTS CO.

Factory at Manchester, Michigan

DISTRIBUTORS OF DOUBLE-A HYDRAULIC HI-SPEED VALVES

Distributors of Double A Hydraulic Hi-Speed Valves

Charles F. Wheelock & Associates, Birmingham Alabama
Gibson Engineering Co., Boston, Mass.
E. C. Neal Company, Inc., Buffalo, Rochester, Syracuse, N. Y., Erie, Pa.
Power Hydraulics, Chicago, Ill.
Euclid Machine and Sales Co., Cleveland, O.
Henry M. Wood Company, Cincinnati, Ohio

DOUBLE A
Hydraulic
HI-SPEED
Oil Control Valves

Slaybaugh - Thompson Company, Denver, Colo.
Tec Engineering Corporation, Logansport, Ind.
Alex M. Sneddon, New York, N. Y.
The Rucker Company, Los Angeles, Calif.; Oakland, Calif.; Portland, Ore. (West Coast Stock)
The Battersby Company, Philadelphia, Pa.
J. Boyd Coates, Philadelphia, Pa.
George Worthington, St. Louis, Mo.
Dwight A. Johnston, Youngstown, Ohio.

10. Flexible Tubing . . . Titeflex all-metal flexible tubing is illustrated and described in a 24-page Catalog No. 113 recently published by Titeflex, Inc. Tubing of many different compositions — brass, bronze, monel, stainless steel and inconel— are available in sizes ranging from 3/16 to 3 in diameter. Specifications for standard fittings and illustrations of typical assemblies are shown. Also described are bendable pipe, high frequency conductors and vibration eliminators. Cross-sectional drawings are used throughout.

11. Solenoids . . . A four-page bulletin has been prepared by Guardian Electric Mfg. Co. to aid in the selection of solenoids for specific jobs. The ac and dc units shown are for intermittent duty or for continuous duty on circuits ranging from 6 to 230 volts. Design drawings and photographs of each unit type are included and in addition operating data is charted for each type.

12. Air Powered Devices . . . The Bellows Co. describe in Bulletin CL-10-R "Controlled-Air"devices for repetitive operation applications. Air motors and cylinders, power feeding units, electrically controlled power feeds, air vises, hydraulic checking units and control valves and assessories are shown. Photographs are used throughout; equipment types and typical applications and installations are shown. The air motors are available in four power rated sizes—1, 5, 10 and 15 times air supply pressure—and the air cylinders in three sizes—4, 6 and 8 in bore.

13. Hydraulic Check Valves . . . Greer Hydraulics, Inc. are distributing a four-page pamphlet showing their hydraulic check valves. The valves can be use for hydraulic fluid, oil or other fluids. It is a poppet type design for use on high or low pressure systems. Offered in 1¼ in size; other sizes supplied on request. Burst pressure is 8000 psi; rate of flow is 30 gpm. Photographs, drawings and a performance chart are included.

14. Pneumatic Products . . . The pneumatic products offered by C. A. Norgren Co. are described in Catalog No. 400d. Automatic air line lubricators, horizontal and vertical types; regulating and reducing valves, with floating diaphragm; and relief and check valves are some of the products shown. Also included are air hose couplings and fittings, and high pressure hydraulic hose assemblies. Schematic drawings show typical installations; photographs reveal the types of equipment.

15. Variable Delivery Pump . . . Bulletin 44200 describes the operation and construction of the variable delivery feed pump manufactured by The Oilgear Company. This unit, the combination of a gear pump for rapid traverse and a radial piston pump for accurate feed speeds, provides a range of feed and rapid traverse speed ratios. Ratios are from 13:1 to 265:1: Feeding pressures are 1000 psi and traverse pressures are 300 psi. Schematic drawing show typical installations and design drawings reveal construction of this pump and of power units incorporating this pump.

16. Hydraulic "O" Rings . . . An engineering manual on hydraulic "O" rings has been prepared by Crane Packing Company. It contains tabulations of compound specifications and dimensional standards for application of these rings. Recommendations covering reciprocating and static seals and drawings showing typical problems of "O" ring usage are included.

17 Combination Hydraulic Pump . . . The PWX series of power units, consisting of variable displacement and constant displacement pumps and control valves, are reviewed in Bulletin No. 129 prepared by Sundstrand Pump Division, Sundstrand Machine Tool Co. The variable volume pump develops 1000 psi; the constant volume pump 500 psi. Two models are available for feed appli-

(Continued on next page)

BOOK REVIEWS

(Continued from Page 35)

tatively. Theoretical treatments have been reduced to the very minimum necessary to a clear understanding of the problems involved.

After an introductory chapter, a chapter is devoted to definitions, then six to selection, applications and circuits, typical relays, relay components, auxiliary installation and service. Three final chapters are devoted to standards, bibliography and appendix. There is also a very satisfactory index. For any industrial engineer who must or should be conversant with the practical fundamentals of relays and relay engineering, this little manual is a must.

Instrument and Control Manual

Eugene W. Feller. *Operating Engineer, Associate Editor of Power. First Edition. 426 pages, 5½ x 8 inches. Published by McGraw-Hill Book Company, Inc., at $6.00.*

An up-to-date guidebook for the man in the plant who wants fingertip information on the principles of control and on the construction and operation of indicators and controllers of all types. It describes and illustrates the most modern instruments for measuring and controlling liquid levels, pressure, temperature, speed and humidity and provides trouble-shooting data that will enable the operating engineer to keep control systems functioning.

In 16 well-organized chapters this manual takes up the mechanical characteristics and efficient operation of each important unit or type now available—cross-sectional views and schematic diagrams clarify the operation of the components of each instrument. It also includes vital information concerning the physical reactions introduced into systems by various controllers and shows how and where indicators and controllers should be installed for best results. Over 500 drawings and charts are included.

cation in one direction and two models are available for feed in both cylinder directions. Mounting drawings are included for each of the models; schematic illustrations show typical machine tool applications.

18. Air Compressors . . . Catalog No. 216 reviews the single-stage and two-stage air compressors manufactured by Kellogg Division of American Brake Shoe Company. Unmounted, base plate, vertical tank and horizontal tank mounted units are offered. Horsepowers range from ¼ to 12 for electric or gasoline powered units. The first six pages of this catolog are devoted to basic engineering data on selecting air compressors and to construction details of these units.

19. Couplings . . . Catalog No. 47 shows the line of quick-connective couplings produced by The Hanson Manufacturing Company. Series 3000, 5000 and 6000 are recommended for pneumatic and hydraulic service. Series 8000, with shut-off valves in both socket and plug, is recommended for hydraulic service. Photographs and cutaway drawings showing the constructional details of each type of coupling are included. The last five pages are devoted to engineering data on installation and selection.

20. Double Pump Unit . . . Double pump and combination valve units, for hydraulic operations utilizing traverse and feed cycles, are described in Bulletin 38-14 prepared by Vickers Incorporated. Two balanced vane constant volume pumps, unloading valve and relief valve are included in this combination unit; gives effect of variable delivery pump having two preselective steps. Flange and foot type mountings are available. Capacities range from 5 to 45 gpm and continuous operating pressures to 1000 psi. Design drawings showing construction features and tables list electric motor sizes required for operating needs.

PERSONALS

MEL W. LEWIS has been promoted to branch manager of the Cleveland factory office, General Controls Co., according to an announcement by J. F. Day, director of sales. Lewis has been associated with this company for the past ten years.

RICHARD HAYMAN, president of Haskel Engineering Company, Glendale, California announces the appointment of his organization as the representatives for The Meletron Corp., Los Angeles. They will be exclusive representatives for the George A. Starbird pressure and vacuum actuated switches.

Mr. Hayman

L. H. LITTLEFIELD has been appointed general sales manager for the Wolverine Tube Division, Calumet & Hecla Consolidated Copper Co., Inc., Detroit. He was formerly affiliated with the Holzer-Cabot Division of the First Industrial Corp.

JOHN K. McNEELEY has been appointed special aviation project engineer for Jack & Heintz Precision Industries, Inc., Cleveland.

FELIX WUNSCH has retired after serving Leeds & Northrup Co., Philadelphia, since 1905. He was associated with the engineering staff. Paul V. Roth, shop engineer, with 46 years service, also retired.

GEORGE SQUIBB has been appointed chief engineer of Detroit Broach Co., Detroit. He will succeed Leon Caplen who resigns after 13 years as chief engineer. Caplen will continue as consulting engineer for the company.

ROBERT E. HARTSOCK has been made chief engineer of Earthmaster Division, Adel Precision Products Corp., Hollydale, Calif.

LUKE E. SAWYER has been elected executive vice president and a director of the Babcock & Wilcox Tube Co., New York. He takes over the management of the company following the death of Peter D. White, former president. Paul J. Utnehmer has been named manager of manufacturing at the Beaver Falls, Pa., and Alliance, Ohio, plants.

I. F. KINNARD has been named manager of engineering of the meter and instrument division, General Electric Co.

PAUL R. OLIVER has been named west coast manager for the Farrel-Birmingham Co., Ansonia, Conn. The district office will be located at 2039 Santa Fe Ave., Los Angeles, Calif.

DANIEL B. BAUER has been named general factory manager of Flodar Corporation, Cleveland, Ohio, manufacturers of fittings for the hydraulic industry. In this position he will be in general charge of manufacturing, production and purchasing. Before joining Flodar Corporation, Bauer was production superintendent of Morgan Service, Inc., also of Cleveland.

Mr. Bauer

JAMES M. WHITE has been named to the production management staff of Allen-Bradley Co., Milwaukee. White formerly was vice president in charge of manufacturing at the Milwaukee plant of Allis-Chalmers Co.

DWAIN E. FRITZ has joined the development engineering staff, Jack & Heintz Precision Industries, Inc., Cleveland. He will be manager of the special aviation projects section. For the past two years Fritz has been associated with Westinghouse Electric Corp. at its Lima, Ohio, plant.

J. L. ATWOOD has been elected president of North American Aviation, Inc., succeeding J. H. Kindelberger who was elected chairman of the board.

WILLIAM T. BOYCE has been appointed advertising manager of Weatherhead Co., Cleveland. He was formerly assistant to the advertising manager at American Steel & Wire Co., Cleveland subsidiary of U.S. Steel Corp.

EDWARD A. ASH of F. L. Jacobs Co., Detroit, has been appointed chairman of the Rocket, Jato (Jet Assist Take-off), Guided Missile Committee for the Army and Navy, by the American Ordnance Association. He will assist on projects designed for national defense.

RAY CALDWELL has been appointed representative for the northeast district of New York Belting & Packing Co. This territory covers New England, metropolitan New York, northern New Jersey and eastern Pennsylvania. Headquarters will be located in New York.

PHIL HUBER, president of Ex-Cell-O Corp., has been elected to the board of directors, Mid-West Abrasive Co., Detroit.

GEORGE REED has been appointed sales engineer of The Timken Roller Bearing Company, Steel and Tube Division with headquarters in Houston. Reed was a metallurgical engineer with the same company.

ALLEN A. WATSON has been named sales manager of the Trumbull Electric Mfg. Co., Plainfield, Conn.

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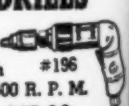

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